

New Scientist

WEEKLY 19 August 2023



CLIMATE CHANGE: A SPECIAL ISSUE

HOW WORRIED SHOULD WE BE?

Your guide to a year of extreme weather

Is the world
warming faster
than expected?

Can humans
adapt to soaring
temperatures?

Why both
doomers and
deniers are wrong

Renewables
rocket as big
emitters go green

PLUS THE TRUTH ABOUT ULTRA-PROCESSED FOODS /
LK-99 NOT A SUPERCONDUCTOR AFTER ALL /
THE UNIVERSE'S MOST AMAZING LIGHT SHOWS

No3452 £6.95 CAN\$9.99





DS AUTOMOBILES

Spirit of Avant-Garde

THERE'S A REASON
SAVOIR-FAIRE IS FRENCH

DS 7

PARISIAN SAVOIR-FAIRE



Scan to explore



[DSautomobiles.co.uk](https://www.dsautomobiles.co.uk)

DS prefers TotalEnergies – FUEL CONSUMPTION AND CO₂ FIGURES FOR DS 7: MPG L/100KM: COMBINED 48.7/5.8 TO 250/1.1, CO₂ EMISSIONS: 106 - 26 G/KM. ELECTRIC ONLY RANGE UP TO 43 MILES (WLTP).

The fuel consumption or electric range achieved, and CO₂ produced, in real world conditions will depend upon a number of factors including, but not limited to: the accessories fitted (pre and post registration); the starting charge of the battery (PHEV only); variations in weather; driving styles and vehicle load. The plug-in hybrid range requires mains electricity for charging. The WLTP (Worldwide Harmonised Light Vehicles Test Procedure) is used to measure fuel consumption, electric range and CO₂ figures. Figures shown are for comparison purposes and should only be compared to the fuel consumption, electric range and CO₂ values of other cars tested to the same technical standard. The figures displayed for the plug-in hybrid range were obtained using a combination of battery power and fuel. Information correct at time of going to print. Images shown for illustration purposes only. Some features may be standard or optional extras available at additional cost depending on specification. Visit www.dsautomobiles.co.uk for further details.

This week's issue

On the cover

How worried should we be?
Your guide to a year of extreme weather

10 Is the world warming faster than expected?



Vol 259 No 3452
Cover image: George Peters/Getty Images / Nikolay Tsuguliev/Alamy / Art worked by Ryan Wills

30 Can humans adapt to soaring temperatures?

13 Why both doomers and deniers are wrong

12 Renewables rocket as big emitters go green

16 The truth about ultra-processed foods **14** LK-99 not a superconductor after all

38 The universe's most amazing light shows

34 Features
“Gesture lightens our cognitive load, making thinking easier”

News

15 Night moves
What you listen to before you sleep can shape your dreams

15 Martian weather
The Red Planet used to have wet and dry seasons

16 No males needed
Female stick insect clones itself despite sex with males

Views

21 Comment
Knowing how climate change exacerbates extreme weather is key, says Friederike Otto

22 The columnist
Chanda Prescod-Weinstein on Isaac Newton's laws

24 Aperture
Farming seagrass

26 Culture
Why we should study how we grow from embryos

29 Letters
The real cause of obesity has yet to be confronted

Culture



27 Getting an edge How data is turning sport into even bigger business

Features

30 Feel the heat
How extreme temperatures affect our brains and bodies

34 Express yourself
The hidden power of hand gestures

38 Cosmic fireworks
From supernovae to stellar flares: your guide to the biggest bangs in the universe

The back pages

44 Mathematics of life
How to boost your lottery chances

45 Puzzles
Try our crossword, quick quiz and logic puzzle

46 Almost the last word
What was used to wean babies in prehistory?

48 Feedback
A case of mistaken AI identity and baring one's teeth

48 Twisteddoodles for New Scientist
Picturing the lighter side of life

NS Live

Why we need more women in science

Physicist Athene Donald will be at New Scientist Live on 8 October to explore the systemic disadvantages that women in science face. Her talk will dispel persistent myths about “gendered” brains and what attributes are needed to become a successful scientist. Now, more than ever, there is a moral and business case for greater diversity in research, she says.

[newscientist.com/nsimag](https://www.newscientist.com/nsimag)

Weekender

Mysteries of the universe, Cheshire, UK

From black holes to the big bang, explore the cosmos in this getaway featuring talks from some of the brightest minds in astrophysics. Visit the iconic Lovell Telescope at the Jodrell Bank UNESCO World Heritage Site. Plus, go stargazing with *New Scientist* features editor Abigail Beall. This weekender runs from 29 September to 1 October and costs £959.

[newscientist.com/tours](https://www.newscientist.com/tours)

Podcast

Weekly

This episode, the team has a close look at a new nuclear fusion milestone and whether it really means clean, limitless energy. There is also a project to map what we don't know about how genes make proteins. Plus, Russia and India's race to the moon's south pole and what we can learn about ancient ecology from fossilised poo.

[newscientist.com/nspod](https://www.newscientist.com/nspod)

Weekender



ANL/SHUTTERSTOCK

Lovell Telescope Unravel the night sky with our cosmic experts

Newsletter



ROLAND SEITRE/NATUREPL

Honey helper The truth behind this African bird's beehive antics

Video

Wolf Road

Anthropologist Alice Roberts has published her first children's novel, *Wolf Road*, set during the last glacial period. It follows Tuuli, a girl who meets a strange boy on the journey to her tribe's summer camp. In this interview, culture editor Alison Flood's daughter Jenny is calling the shots: “Did people back then think just like you and me?” she asks.

[youtube.com/newscientist](https://www.youtube.com/newscientist)

Newsletter

Wild Wild Life

In an act of companionship, an African bird called the greater honeyguide may get a honey badger to help it break into a beehive so the two can share the plunder. Michael Marshall finds that, despite reports, this animal behaviour might not happen after all – but surprising truths lie behind the fables.

[newscientist.com/wild-wild-life](https://www.newscientist.com/wild-wild-life)

Podcast

“Parasites feel like gross nuisances, but they offer clues to the ecology of ancient animals”



Essential guide

What drives the ageing process? What can science tell us about the stages of life? And how can we use the latest research to live healthily into old age? This *New Scientist Essential Guide* offers some fresh insight. Available to download in the *New Scientist* app or to purchase in print from our shop.

shop.newscientist.com

aramco



powered by how

how

can more women
drive innovation in
our industry?

Women continue to be underrepresented in fields such as science, technology, engineering and math.

This reality inspired a series of initiatives designed to accelerate women's professional development within our operations. This approach has produced an outcome which signals a more promising future; Aramco's growing cohort of female researchers have been named as inventors on 352 granted U.S. patents and counting.

Discover how our female talent is pushing the energy industry forward at aramco.com/poweredbbyhow

The right amount of worry

We must remain active, not fearful, in the face of climate change



COSTAS BALTA/ANADOLU AGENCY VIA GETTY IMAGES

LIKE many aspects of modern life, our response to climate change seems to be increasingly polarised. On one side, we have people saying that rising temperatures mean the world as we know it is just decades from ending and there is nothing we can do to prevent that. On the other, we have those who claim the very notion of human-made climate change is an international conspiracy.

Neither of these extreme positions holds up to scrutiny. Climate change caused by humans isn't a conspiracy theory, but it is equally true that global catastrophe isn't a foregone conclusion.

What is certain is that the increasing levels of greenhouse gases in our atmosphere are raising temperatures worldwide, and this process will continue until we stop emitting more of them. In other words, climate change is happening, and we can stop it if we choose to. What is uncertain is what we are actually going to do to combat it.

So we have both certainty and uncertainty to deal with – “known knowns” and “known unknowns”, to echo former US secretary of defence Donald Rumsfeld. Unfortunately, humans, both at an individual and societal level, are poorly equipped to deal with such a combination.

Take the known knowns first. Deniers aside, most people are aware that climate change is happening and we need to do something about it. The trouble is, this known is so well known that it has become part of the background hum of everyday life. Very few of us are able to spend an exactly proportionate amount

of time worrying about climate change, given everything else that the world demands we pay attention to – whether that be our jobs, our families, rising inflation, poverty or even war.

“Psychologically, we are completely unsuited to cope with long-term, steadily increasing problems,” says Katherine Hayhoe at Texas Tech University (see page 13). And because public sentiment varies, so, too, does political will to tackle the issue: at the moment, very few governments are willing to have honest conversations with voters about the costs, risks and benefits of addressing climate change, beyond broad pledges to reach net-zero emissions without actually specifying how.

Climate activists, including Greta Thunberg and the Just Stop Oil movement in the UK, have used a variety of forms of protest in an attempt to raise awareness of climate change above the background noise of daily life. Yet despite their efforts, a recent YouGov poll of UK adults found that they felt the environment was only the fourth most important issue facing the country, following the economy, health and immigration. Ironically, all of these issues will be massively affected by a warming world, which will harm productivity, cause early deaths and increase migration as people seek to get away from parts of the world that are becoming ever more unliveable.

Extreme events, as we have just experienced in July with the hottest month on record (see page 8), focus the mind more than dystopian predictions of the future, but even then reactions can be mixed. For example, record temperatures in Death Valley,

California, have become a tourist attraction, in a bizarre form of climate rubbernecking.

One way of clarifying the link between such events and the long-term climate trend is the burgeoning science of climate attribution studies (see page 21). While we might once have had to talk in generalities, saying that certain types of events will be made more likely by climate change, we can now be specific. According to the World Weather Attribution initiative, the heatwaves in the US and Europe this July would have been “virtually impossible” in a world without human-driven climate change.

Let’s turn now to the known unknowns. For people already engaged with the risks of climate change, these are the biggest worries. Should we have predicted July’s extreme weather? Is global warming worse than we expected? How will we adapt to extreme heat (see page 30)? Could we experience cascading “tipping points” that result in runaway warming? These are all valid questions, and ones we have attempted to address (see page 10). But to focus on them to the extent of paralysing action, as some doom-mongers do, is the equivalent of letting fears of a deadly car crash prevent you from moving the steering wheel to avoid it.

Then there are the unknowns related to our actions. Can we decarbonise fast enough to avoid the worst climate scenarios? Will we be able to make unproven technologies like carbon capture and storage work? These are

“Very few of us spend an exactly proportionate amount of time worrying about climate change”

harder to answer and require much more crystal ball-gazing, but the good news is that the transition to renewables is happening faster than you might realise, with strong action from both the US and China. In fact, we may be just a few years away from the beginning of the end for fossil fuels (see page 12).

Finally, there is the unknown at the heart of all our climate anxiety: just how worried should we be? *New Scientist* can’t answer that for you directly – a reader in a richer country with easy access to air conditioning is going to fare far better in the coming decades than one in a poorer island nation threatened by rising sea levels. What we can do, as we have attempted in this special issue, is to always provide you with a clear and sober assessment of the science. No doom. No denial. Just reality. ■

NewScientist

EDITORIAL

Editor-in-chief Emily Wilson
Magazine editor Catherine de Lange
News and digital director Penny Sarchet
Creative director Craig Mackie

News

News editor Jacob Aron
Assistant news editors Chris Simms, Alexandra Thompson, Sam Wong
Reporters (UK) Madeleine Cuff, Michael Le Page, Chen Ly, Jason Arunn Murugesu, Matthew Sparkes, Alex Wilkins, Clare Wilson, (Aus) Alice Klein

Digital

Acting head of digital Matt Hambly
Podcast editor Rowan Hooper
Head of editorial video David Stock
SEO and analytics manager Finn Grant
Social media manager Isabel Baldwin
Intern Obomate Briggs

Features

Head of features Daniel Cossins and Helen Thomson
Editors Abigail Beall, Kate Douglas, Alison George, Joshua Howgego, Thomas Lewton
Feature writer Graham Lawton
Culture and Community
Comment and culture editor Alison Flood
Senior culture editor Liz Else

Subeditors

Chief subeditor Eleanor Parsons
Bethan Ackerley, Tom Campbell, Tom Leslie, Jon White

Design

Art editor Ryan Wills
Joe Hetzel

Picture desk

Picture editor Tim Boddy
Assistant picture editor Jenny Quiggin

Production

Production manager Joanne Keogh
Production coordinator Carl Latter

New Scientist US

US Editor Tiffany O’Callaghan
Editors Timothy Revell, Chelsea Whyte
Subeditor Alexis Wnuk
Deputy audience editor Gerardo Bandera
Reporters Leah Crane, James Dinneen, Jeremy Hsu, Karmela Padavic-Callaghan, Christie Taylor, Grace Wade, Corryn Wetzal

CONTACT US

newscientist.com/contact

General & media enquiries

UK Tel+44 (0)203 615 6500
9 Derry Street, London, W8 5HY
Australia 58 Gipps Street, Collingwood, Victoria 3066
US PO Box 80247, Portland, OR 97280

UK Newsstand

Marketforce UK Ltd
Email mfcommunications@futurenet.com

Syndication

Tribune Content Agency **Tel** +44 (0)20 7588 7588
Email tca-articlesales@tribpub.com

Subscriptions

newscientist.com/subscription

One year print subscription (51 issues) UK £270
Tel +44 (0)330 333 9470

Email subscriptions@newscientist.com
Post New Scientist, Rockwood House, Perrymount Road, Haywards Heath, West Sussex RH16 3DH

Chief executive Nina Wright
Managing director Laurence Taylor
Executive assistant Lorraine Lodge

Finance & operations

Chief financial officer Ameer Dixon
Commercial finance manager Charlotte Thabit
Commercial finance manager Anna Labuz
Management accountant Charlie Robinson
Commercial management accountant Alexandra Lewis

Human resources

HR business partner Purnima Subramaniam

PUBLISHING & COMMERCIAL

Commercial and events director Adrian Newton

Display advertising

Tel +44 (0)203 615 6456 **Email** displayads@newscientist.com
Sales director Justin Viljoen
Account manager Mila Gantcheva
Partnerships account manager David Allard

Recruitment advertising

Tel +44 (0)203 615 6458 **Email** nssales@newscientist.com
Recruitment sales manager Viren Vadgama
Key account manager Deepak Wagjiani

New Scientist Events

Tel +44 (0)203 615 6554 **Email** live@newscientist.com
Sales director Jacqui McCarron
Head of event production Martin Davies
Head of product management (Events, Courses & Commercial Projects) Henry Gomm
Marketing manager Emiley Partington
Marketing executive Naomi Edge
Events and projects executive Georgia Peart
Events and projects coordinator Gemma Dowie
Events team assistant Olivia Abbott

New Scientist Discovery Tours

Director Kevin Currie
Senior product manager Lara Paxton

Marketing & Data

Marketing director Jo Adams
Head of campaign marketing James Nicholson
Digital marketing manager Jonathan Schnaider
Campaign marketing coordinator Charlotte Weeks
Head of customer experience Emma Robinson
Senior customer experience marketing manager Esha Bhabuta
Marketing executive Bethan Smith
Head of CRM & audience data Rachael Dunderdale
Senior email marketing executive Natalie Valls
Email marketing executive Ffion Evans
Junior analyst Hamied Fahim

Technology & Product

Head of strategy and product development Clarissa Agnew
Director of strategic programmes and technology Jennifer Chilton
Head of engineering Tom McQuillan
Senior developer and UX designer Amardeep Sian
Senior developers Maria Moreno Garrido, Piotr Walków
Lead digital designer and developer Dan Pudsey
Front end developer Damilola Aigoro
Junior front end developer Matthew Staines



© 2023 New Scientist Ltd, England. New Scientist is published weekly by New Scientist Ltd. ISSN 0262 4079. New Scientist (Online) ISSN 2059 5387. Registered at the Post Office as a newspaper and printed in England by Precision Colour Printing Ltd

Subscriptions

NewScientist



Only
£1
a week

Big summer reads... *amazingly* small price

From understanding the baffling problem of infinity to the joy of curiosity, you'll find it all and more with *New Scientist*. Your essential reading is available in print, via our app and at newscientist.com for £1 a week.

Visit **newscientist.com/20312**
or call +44 (0) 330 333 9470, quoting 20312

Scan me for
instant sign-up
on your phone



*Offer available on "digital access" and "print and digital access" packages. These are auto-renewing subscriptions. In the unlikely event that you wish to cancel your subscription, we offer a 14-day cooling-off period after the initial payment is made. Offers with trial periods can be cancelled in the trial period and no further payment will be taken. Offer ends 10 September 2023.

Back with a bang

Russia launches its first lunar mission in nearly 50 years **p17**

Disease predictor

Blood test could aid the diagnosis of 52 conditions **p17**

Bacterial beginnings

Ocean microbes may be closest relatives of mitochondria **p18**

Kill or be killed

Young spiders turn cannibal and eat their siblings **p18**

Cleaning up

Plastic bottles and bags can be recycled into soap **p19**



Extreme weather

Wildfires wreak havoc in Hawaii

The wildfires that first hit Hawaii on 8 August are the deadliest in the US for more than 100 years. More than 1000 people are thought missing and about 100 are known to have died, chiefly on the island of Maui. The fires were fuelled by dry conditions and strong winds from Hurricane Dora (turn to page 8 for our climate special report).

Record temperatures

What on Earth is going on?

Extreme weather and temperatures made July 2023 a shocking month, highlighting the precarious state of the climate, says **James Dinneen**

JULY 2023 was the hottest month on record, the European Centre for Medium-Range Weather Forecasts confirmed on 8 August. More broadly, this year's overall global average temperature is shaping up to be the hottest ever measured.

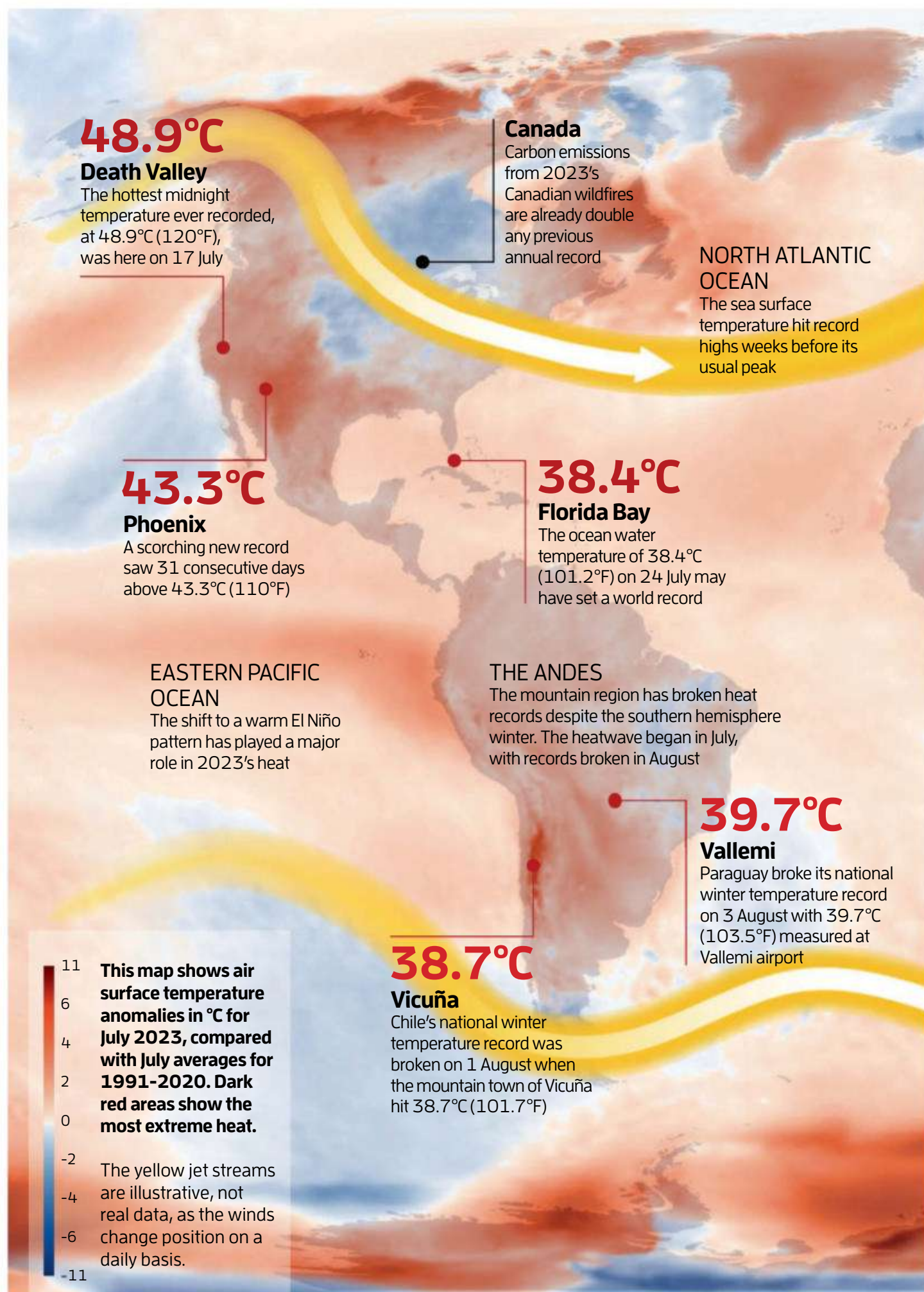
The main reason for these extremes is the long-term effect of humans releasing ever more greenhouse gases into the atmosphere, plus the shift to a warm El Niño pattern in the Pacific Ocean, says Michael McPhaden at the US National Oceanic and Atmospheric Administration.

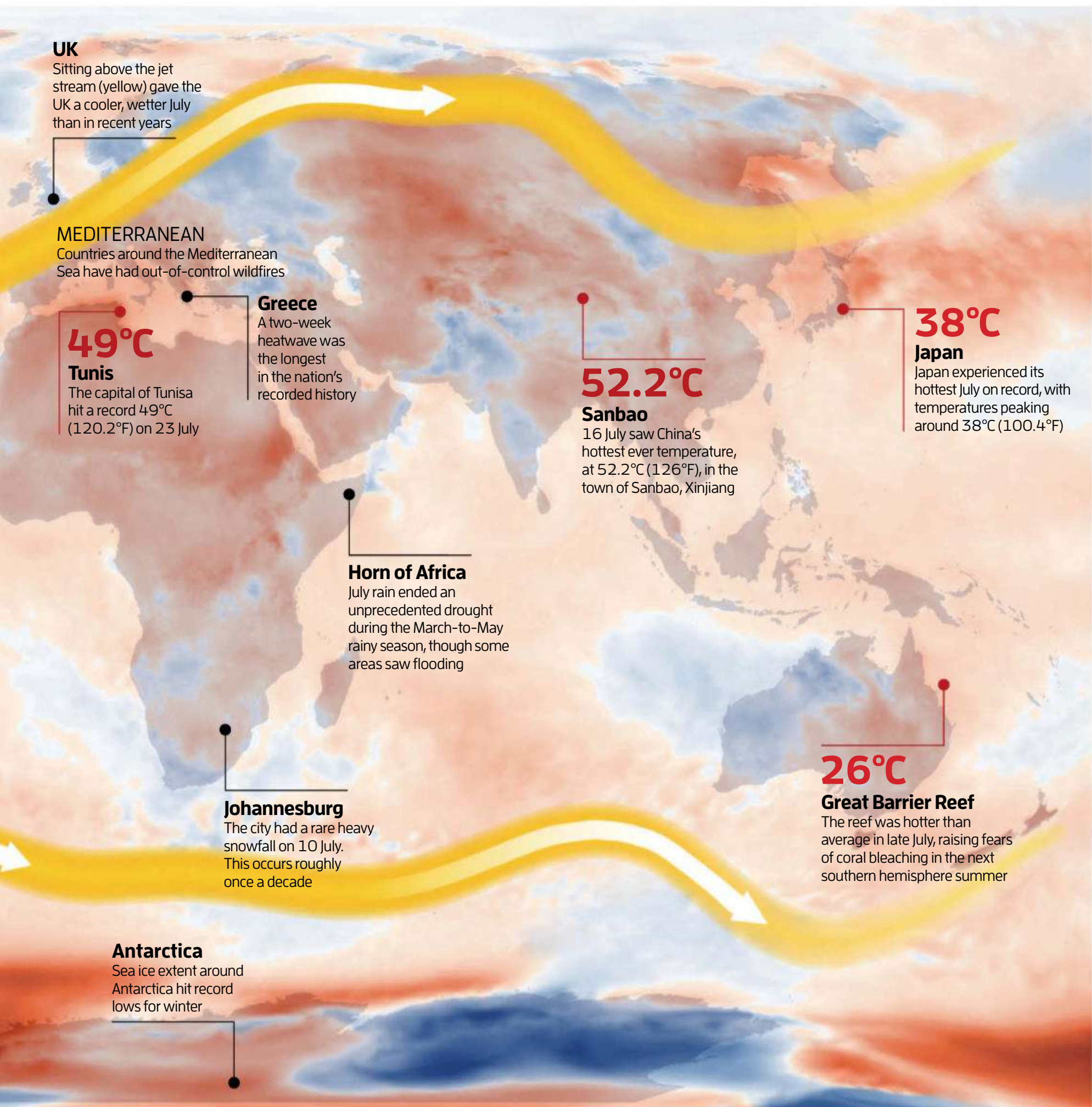
He says El Niño's effect is especially striking after several cooler years in the Pacific "masked" a steady rise in the atmospheric concentration of carbon dioxide – an increase of about 4 per cent since the last big El Niño in 2016.

The heat was also boosted by a wavy jet stream pattern (in yellow, right) that formed simultaneous "heat domes" of trapped hot air in North America, Europe and China. Whether climate change makes such heat domes themselves more likely is an active area of research.

While this explains the lion's share of the heat, natural variability and other factors may also be behind local extremes. For instance, a natural warm phase in the North Atlantic Ocean has contributed to record sea surface temperatures there. Other factors, from a deficit of reflective sand blown off the Sahara desert to a drop in sulphur emissions from ships following new regulations in 2020, may also be at play. Water vapour injected into the stratosphere by the 2022 eruption of Hunga-Tonga Hunga Ha'apai in Tonga could also have had a marginal global warming effect.

But, generally, climate researchers aren't surprised. "Nothing in the physical climate side that is happening now is unexpected," says Andrew Dessler at Texas A&M University. With El Niño likely to strengthen and emissions rising, don't expect 2023 to hold on to its records for long. ■





DATA SOURCE: ERA5. CREDIT: COPERNICUS CLIMATE CHANGE SERVICE/ECMWF

Briefing

Is it worse than we thought it would be?

With many records tumbling, it is only natural to worry that climate change is accelerating, but the reality is far more nuanced, explains **Michael Le Page**

UNPRECEDENTED bouts of extreme weather and related events around the world (see page 8) raise the question of whether climate scientists have underestimated how fast the world is warming and how severe the consequences will be. Here are the key facts you need to know.



Is the world warming faster than we expected?

No, it isn't. The rise in the average global surface temperature measured so far is well within the range that climate models have projected for levels of greenhouse gases that resemble those actually observed so far.

Even the projections of the first simple models created in the 1970s are pretty close to what has happened since then, and the increasingly sophisticated models that followed have proved to be even better at forecasting the warming to date.

"If anything, temperatures have been a bit on the low end," says Zeke Hausfather at US non-profit Berkeley Earth.

This July, global average surface temperatures suddenly soared to their highest levels to date, but this is probably natural variability, driven by events such as El Niño, a warming of waters in the Pacific. It will take a decade or so for it to become clear whether there is any change in the long-term trend.

However, while current global climate policies are thought to put Earth on track to warm by 2.7°C or so above pre-industrial levels by 2100, we could yet exceed this.

The performance of computer models so far suggests that they are good at forecasting how much global warming a given level of greenhouse gases will produce. However, there is still a lot of uncertainty about climate



SEBNEW COSKUN/ANADOLU AGENCY VIA GETTY IMAGES

Melting icebergs near Horseshoe Island in Antarctica in February

such anomaly ever recorded on Earth. That was followed by the worst heatwave in human history, with China enduring months of record-breaking warmth during its summer.

Are weather events of this kind more extreme than those the Intergovernmental Panel on Climate Change (IPCC) has projected for the current level of warming? Here the picture is less clear.

"I have yet to see hard evidence that our physical assessment of climate change is an underestimate," says Piers Forster at the University of Leeds in the UK, though he adds that his views are shifting and he does now think this is at least possible. "We don't have enough statistical information to tell us if there is anything that is really outside our predictions," he says.

"For the record-breaking extremes, in both temperature and rainfall, I think there is some evidence that the main IPCC models tend to underestimate these," says Peter Stott at the Met Office, the UK national weather service. "But the jury is still out."

The fundamental issue here is that most of the simulations used are designed to model climate, or average weather, over decades or centuries. They don't have enough resolution to model individual weather events in detail over shorter periods of days or weeks, for example, though researchers are now starting to use higher-resolution models for some studies that address this.

Regardless of whether or not recent extreme weather events can be described as worse than forecast, they are horrifying many

2.7°C

Predicted level of global warming by 2100, on current trajectory

2 metres

Potential sea level rise by end of century if emissions are very high

Coral bleaching off the coast of Moorea, French Polynesia



ALEXIS ROSENFIELD/GETTY IMAGES

feedbacks, which could result in more greenhouse gases in the atmosphere than currently expected – for instance, if forests die off at lower levels of heat and drought than expected.

In 2020, Hausfather estimated that there could be up to 25 per cent more warming than currently projected as a result of these uncertainties. "This means that we cannot fully rule out a small chance of close to 5°C warming [by 2100] in a current-policy world where our best estimate is 3°C," he told *New Scientist* in 2021.

Today, Hausfather thinks there is no longer even a small chance of this. "I think the progress made on clean energy does help rule out 5°C warming, though we still cannot exclude the possibility of 4°C warming by 2100."



Are we seeing more extreme weather than predicted?

In March 2022, temperatures up to 38.5°C higher than normal were seen in the interior of East Antarctica – the most extreme

climate scientists. “I do still find it shocking that this is actually happening around the world and in such a rapidly escalating way,” says Stott.



Beyond extreme weather events, have the impacts of our current level of warming been underestimated?

Here the answer is clear: yes, they have. Compared with earlier assessments, the risks of serious impacts “increase to high and very high levels at lower global warming levels” states the 2022 IPCC report on climate impacts.

This change is simply because the observed impacts so far are already more severe than expected. For instance, coral bleaching and die-off events have been more extensive, as have mass tree deaths.

In fact, not only are the impacts worse, the report says, societies are also turning out to be more vulnerable to these effects than thought and adapting to a warmer world is proving harder than thought. “What we can do is limited,” says Forster. “There’s lots of evidence that when people have tried to adapt, this has been insufficient or has not been done in an appropriate way.”

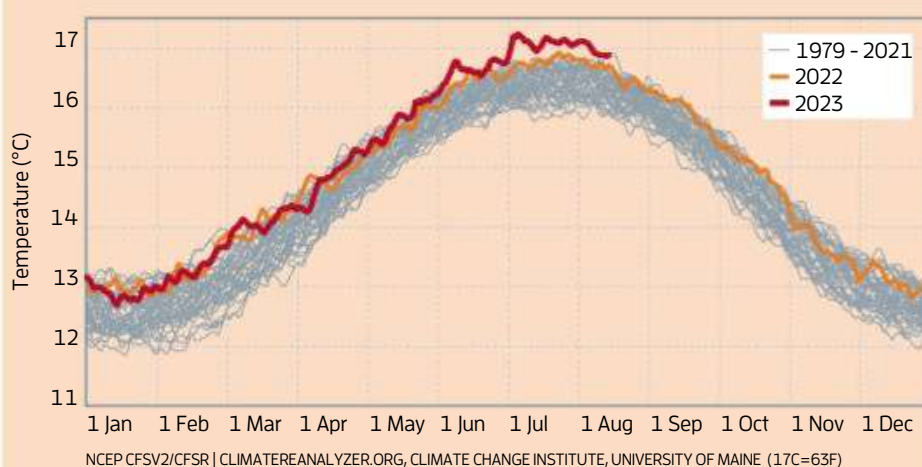
When it comes to future consequences, for sea level rise in particular, IPCC projections have got higher and higher over the years. The 2021 IPCC report says that a global rise of nearly 2 metres by 2100 can’t be ruled out if emissions are very high, whereas its 2007 report had 0.6 metres as the highest possible by 2100.

Stefan Rahmstorf at the Potsdam Institute for Climate Impact Research in Germany has criticised earlier IPCC reports for underestimating the risks of future sea level rise. He thinks the

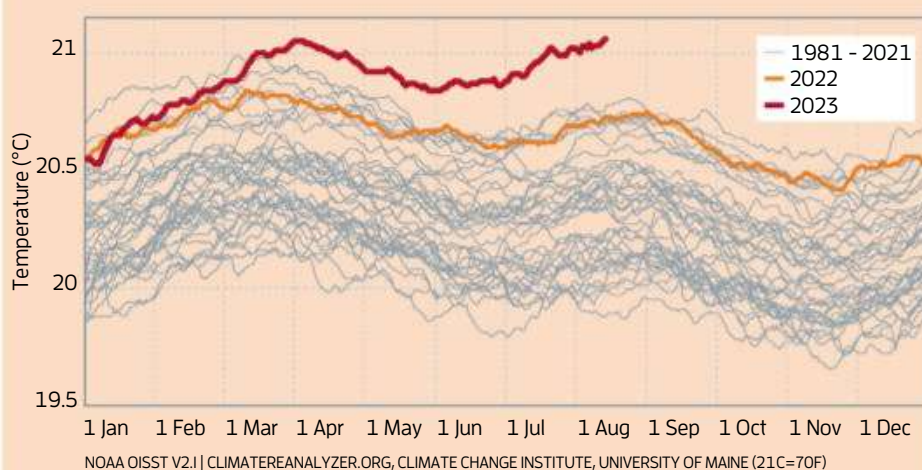
A year of extremes

These three graphs have been shared on social media by both climate scientists and the general public as a way of highlighting just how unusual the climate has been in 2023.

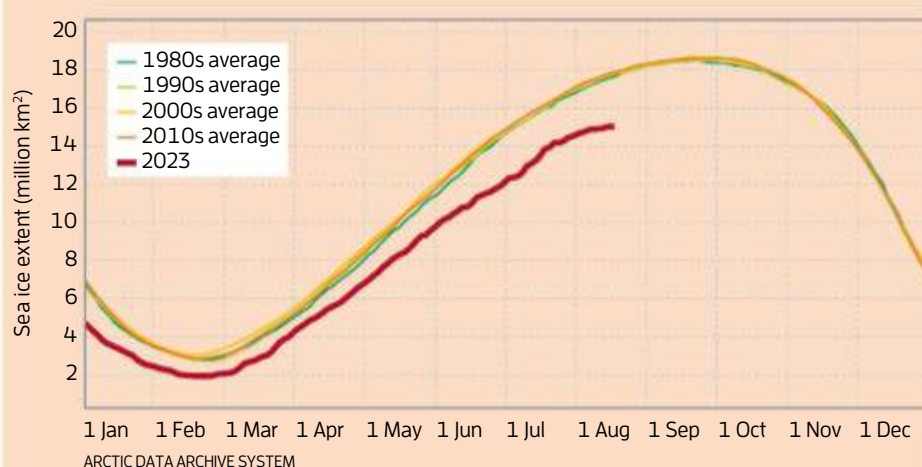
Average global air temperature



Average global sea surface temperature



Antarctic sea ice extent



latest reports are more in line with the science. “I don’t think the IPCC really still underestimates sea level rise,” he says.



Are we closer to tipping points than anticipated?

Yes, we are, though a great deal of uncertainty remains.

The term tipping points refers to large-scale events that can’t be reversed anytime soon if at all if they happen, such as the die-off of the Amazon rainforest or the collapse of the West Antarctic ice sheet. The 2022 IPCC report on impacts says the risks of such events are “higher at both recent and projected warming than” assessed to be the case in its previous assessments.

What’s more, since that IPCC report was written, a number of studies have suggested that the Atlantic meridional

“I do find it shocking this is actually happening around the world and in such a rapidly escalating way”

overturning current (AMOC) may be slowing faster than thought. Among other things, the AMOC keeps northern Europe relatively mild by carrying warmer waters there. If it stops altogether, it would have catastrophic consequences.

“I used to think (as did the IPCC) that the risk of an AMOC collapse this century is less than 10 per cent. Unlike some colleagues, I did not find that reassuring, since I think the consequences would be so disastrous that we really want to rule out such a risk,” says Rahmstorf. “In the light of the [recent] evidence, I now consider that risk to be larger than 10 per cent.” ■

Decarbonisation

And now, the good news

Away from the weather extremes, major greenhouse gas emitters are rapidly transitioning to renewable energy – and fossil fuels may peak sooner than you think, says **James Dinneen**

HEATWAVES on land and at sea. Melting ice. Wildfires. This shocking year of weather extremes has brought home the reality of climate change, but it is also building the political momentum to reduce greenhouse gas emissions. “The upside is a lot of people are going, ‘Holy mackerel, what is going on here?’” says Jennifer Francis at the Woodwell Climate Research Center in Massachusetts.

That sense of urgency is reflected in the unprecedented scale and speed of decarbonisation in many countries across the world. This year is expected to see by far the largest ever addition of wind and solar energy capacity globally, with 440 gigawatts expected to be added in 2023, according to the International Energy Agency (IEA).

Throw in the rising adoption of electric vehicles (EVs), which could account for as much as 18 per cent of all new cars sold this year, and we could be on course for global

440

gigawatts of global solar and wind capacity are to be added this year

fossil fuel emissions to peak by 2025, according to Rystad Energy, a Norwegian research firm. In fact, emissions from the global power sector may already have crested, according to UK clean energy research company Ember.

Much of this speed-up is down to new climate policies in the world’s biggest-emitting countries. China, the global leader in emissions, is building wind and solar (as well as some new nuclear and hydropower) at an almost ludicrously rapid pace to meet its targets of peaking emissions by 2030 and net-zero by 2060, meaning any remaining

emissions are offset. More than half of all new renewables built in 2023 are expected to be in the country. In June, for the first time, fossil fuels made up less than half of China’s power capacity.

China races forwards

EV uptake is also happening fast in China, with the country accounting for 60 per cent of all EVs on roads today. Some EVs in China are now cheaper than comparable fossil fuel-powered cars.

China’s expansion of its coal power plant fleet in the name of energy security has complicated the picture, but this coal boom may only be a temporary surge until expanded clean sources paired with battery storage and a modernised grid can take over. “As long as we can deal with the dirty

side of the picture, the cleaner side will get where we need to be,” says Li Shuo at Greenpeace East Asia.

Meanwhile, after decades of dithering, the world’s second largest emitter, the US, has a coherent and well-funded climate policy in the Inflation Reduction Act. Renewable energy is expected to generate more than a quarter of US energy by 2024, according to the US Energy Information Administration. EVs and electric heat pumps are also selling at record levels. Modelling shows this puts the US on track to more than halve its emissions by 2035, though this is still behind the country’s target of halving emissions by 2030, and the path to reach net zero by 2050 is even more precipitous.

The European Union – the fourth largest emitter after India, where

emissions are expected to rise beyond 2030 – is spending hundreds of billions of euros to slash emissions. The EU’s transition has also been accelerated by Russia’s invasion of Ukraine as the bloc builds renewables and improves energy efficiency to secure energy independence. According to the IEA, forecasts for newly built wind and solar in the EU this year increased by 40 per cent after the invasion. The EU has also said it will push for a global agreement to phase out fossil fuels well before 2050 at the upcoming COP28 climate summit in the United Arab Emirates.

All of this means that global emissions from fossil fuels may soon begin their decline. “It’s very unlikely that we’re going to pass this decade without reaching the peak of fossil fuel emissions,” says Marina Domingues at Rystad.

Of course, there are still substantial non-fossil sources of emissions to deal with, such as from agriculture and deforestation. And some ways we use fossil fuels, such as in aviation and heavy industry, are more difficult to replace with clean sources of energy. But fossil fuels make up the lion’s share of global emissions and seeing them peak would be an important milestone.

The way to net zero from there remains a long and uncertain one, but countries and researchers all over the world are making headway on the many policies and technologies needed to fully decarbonise, from doing more to protect carbon-rich ecosystems to nascent efforts to remove carbon dioxide directly from the atmosphere and put it back underground. This year is already a record one for climate change, but perhaps it may also become a record year for doing something about it. ■



QILAI SHENPANOS



FREDERIC J. BROWN/AFP VIA GETTY IMAGES

Solar panels at the Golmud solar park in China (above) and electric vehicle charging stations in California (left) show how these two big emitters are decarbonising

How hard should we ring the climate alarm bells? Extreme weather events highlight the risks of climate change, but doom-mongering could harm action in the long run, says **Madeleine Cuff**

WILL 2023 mark the arrival of the climate apocalypse – and with it, a call to action? With extreme events and record-breaking temperatures across the world (see page 8), there is certainly a “pervasive sense of doom” among the general public, says Michael Mann at the University of Pennsylvania. “There

“Psychologically, we are unsuited to cope with long-term, steadily increasing problems”

is understandable worry over whether it’s too late, whether we’ve crossed some tipping point.”

The answer to that is complex (see page 10), but as the emerging El Niño climate pattern builds in strength towards the end of the year, researchers agree that further climate records are likely to tumble.

“What’s interesting is that 2024 is actually shaping up to be warmer than 2023, in part because there’s a bit of a lag between the peak El Niño conditions in the tropical Pacific and their effect on global temperatures,” says Zeke Hausfather at US non-profit Berkeley Earth. In fact, an unusually strong El Niño could be enough to make 2024 the first year Earth passes 1.5°C of warming above pre-industrial levels, according to the Met Office, the UK’s national weather service.

What does this mean for climate policy? As growing numbers of people experience the effects of climate change first hand, it will rise to the top of their list of concerns, says Katherine Hayhoe at Texas Tech University, chief scientist at US non-profit The Nature Conservancy.

She says one of the primary barriers people face to taking climate action is “psychological distance”. “You ask people ‘Is climate change real?’ and most people say yes, and then you ask people ‘Will it affect you?’ and the



RONDA CHURCHILL/AFPP VIA GETTY IMAGES

numbers plummet. That is psychological distance,” she says.

That barrier is being “dismantled” by the extreme weather that has already occurred in 2023, says Hayhoe. “Who in the world has not breathed wildfire smoke, or experienced overwhelming heat, or record-breaking floods, or knows people or has been to or used to live in places that have?”

Attention grabbing

Ed Hawkins at the University of Reading, UK, feels similarly. “We often talk about global temperature change, which no one directly experiences,” he says. “But when you live through an extreme weather event, which is being made worse by climate change, then maybe that will help people realise that these are the consequences we’re going to face. And these consequences are only going to get worse.”

Focusing public attention on these “acute” weather events can be a useful way of driving wider engagement with the climate crisis – and convincing those in power to take tougher action to cut emissions, says Hausfather.

But it also comes with risks. When El Niño fades and weather patterns fall back into something resembling “normal”, people’s anxiety about climate change is likely to diminish, warns Hayhoe. “We have the attention span of a cat chasing a laser,” she says. “Psychologically, we are completely unsuited to cope with long-term, steadily increasing problems.”

That could lead to a crash in public – and therefore policy-maker – interest in climate matters during the mid-2020s, when science suggests we should be doubling down on emissions cuts.

Raising the alarm too forcefully right now, including suggesting that Earth has reached some sort of doomsday “tipping point” of no return, could make this potential slump in urgency even more damaging. Last month, the United Nations secretary general, António Guterres, was criticised by some for declaring that “the era of global boiling has arrived”, a term without a clear scientific meaning.

“I appreciate the secretary general’s effort to create a sense of urgency – that is needed,” says Mann. But extreme rhetoric can

Protestor at an unofficial temperature record in Death Valley, California

backfire, he says. “Does ‘global boiling’ cross that line? I’m not sure, but it’s certainly moving in that direction.”

As a warning, Hausfather points to the previous El Niño event in 2015 to 2016, which was one of the strongest on record and resulted in record-breaking global temperatures. When the planet returned to a La Niña state and the wild weather subsided, climate sceptics used the hiatus in global temperature rise as proof that global warming had stalled. The same could happen again after 2024, says Hausfather. “I do think we need to be a little cautious in over-interpreting the role of El Niño as the new normal.”

Mann has similar concerns, warning that “doomism” in the face of extreme weather this year undermines the integrity of climate science and empowers those who argue we should do nothing to combat climate change.

“Doomism – the false notion that there’s nothing we can do – has

“Doomism – the false notion that there is nothing we can do – has become nearly as great a threat as denial”

become nearly as great a threat as denial,” he says. “It is no more valid to equate the extra warmth from El Niño with ‘acceleration’ of global warming than it was for climate deniers to claim that global warming had stopped in the 00s and early 10s because of an extended La Niña.”

So no, this isn’t the apocalypse – but as has always been the case, we do need to take action. “The truth is bad enough,” says Mann. “No need to squander credibility by exaggerating things.” ■

Superconductor hopes dashed

Following a flurry of replication attempts, the claim that LK-99 perfectly conducts electricity at room temperature and pressure looks unlikely to hold up, finds **Karmela Padavic-Callaghan**

JUST weeks after researchers claimed that a material called LK-99 is the world's first room-temperature, ambient-pressure superconductor, evidence to the contrary has started to pile up. Superconductors conduct electricity perfectly, but studies on LK-99 performed at impressive speed from multiple laboratories dispute that the material has this property.

The search for superconductors has long captured attention and interest. Because electricity can pass through them without losing energy, they could greatly improve the efficiency of the power grid, lead to new ways to store energy and improve electronic devices overall. However, all known superconductors are impractical for most uses as they only work under extreme conditions like very low temperatures or very high pressures.

So when Hyun-Tak Kim at the College of William & Mary in Virginia and his colleagues announced that their material, LK-99, superconducts at room temperature and pressure, many people responded with excitement and scepticism.

A flurry of scientific investigations into LK-99 ensued and now a consensus is emerging that the material, as described by its creators, is unlikely to be a superconductor after all.

Researchers have focused on two properties of LK-99 that could reveal its claimed superconductive nature: its resistivity to electricity and its response to magnetic fields.

By definition, a superconductor has zero electrical resistivity, and

Kim's team reported this was the case for LK-99 at temperatures ranging from 30°C (86°F) to 127°C (261°F).

But when other teams, like those in India, China and the UK, made LK-99 they either didn't observe zero resistivity or only saw it at temperatures well below room temperature. Some researchers also questioned whether the original measurements were precise

"We believe that the kind of 'half levitation' we observed has no relation to superconductivity"

enough to distinguish zero resistivity from values too small to be measured by lab equipment.

An experiment by Jianlin Luo at the Chinese Academy of Sciences and his colleagues now indicates that the original zero-resistivity measurement may have been a case of mistaken identity and imprecision. They examined the role of a compound called copper sulphide that was present in the original LK-99 sample, and in those created by other teams.

Luo and his team found that

at about 126°C (260°F) – very close to where initial reports described LK-99 as becoming superconducting – copper sulphide undergoes a phase transition that makes its resistivity decrease sharply (arXiv, doi.org/kn5c). "We believe LK-99 has this phase transition instead of being a superconductor. The electrical resistivity of LK-99 is greatly influenced by the content of the copper sulphide impurity," says Luo.

On the magnetic fields front, viral videos on social media showed LK-99 partially levitating over a magnet, which is an indicator of superconductivity known as the Meissner effect. However, this phenomenon hasn't been consistently observed across replication experiments.

Yuan Li at Peking University in China and his colleagues are among those who have made their own LK-99 sample and found that it has no special conductivity properties but does respond to a magnetic field in an unusual way.

When the researchers measured its magnetic properties more closely, they concluded that the strange behaviour wasn't due to

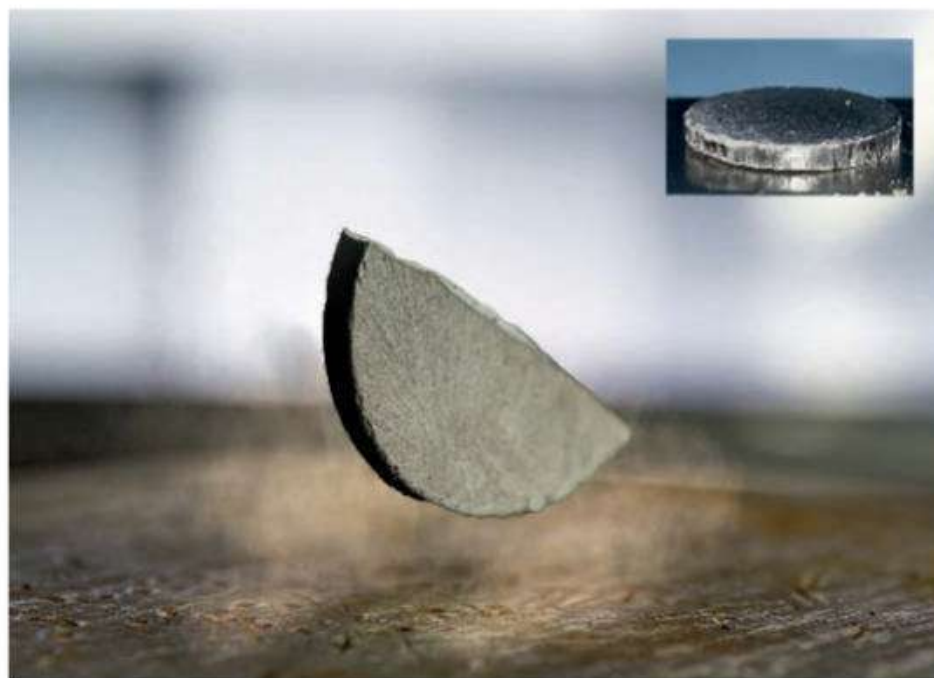
the Meissner effect, but rather, the sample had properties more like those of ferromagnetic materials, such as iron. These become magnetised, and therefore attracted to or repelled from other magnets when immersed in a magnetic field (arXiv, doi.org/kn5d). Li says this plus the shape of their sample, which resembled thin flakes, conspired to produce a magnetic torque that pushes LK-99 to partially levitate above a magnet. "We believe that the kind of 'half levitation' we observed has no relation to superconductivity," says Li.

The new evidence, especially with regards to resistivity, makes a compelling case against LK-99 being a superconductor, says Sankar Das Sarma at the University of Maryland. "Someday we will have room-temperature superconductivity, since it is allowed by the laws of physics, but LK-99 does not look like it," he says.

Susannah Speller at the University of Oxford says that "all the signs so far are that this system has some possibly interesting magnetic properties at room temperature, but as most experts suspected, there is no evidence in the replication studies to support the initial claim of room temperature superconductivity."

She says the explanation for partial levitation by Li's team is plausible, but notes that some uncertainty remains when it comes to how similar the samples of LK-99 in replication studies are to the original sample.

Kim has previously told *New Scientist* that the quality of other researchers' LK-99 samples was behind the initial reports of the absence of superconductivity. He has yet to respond to a request for comment on the experiment from Peking University. ■



Superconducting materials should levitate in a magnetic field, but some samples of compound LK-99 (inset image) refused to budge

Mind

The audiobook you listen to before you sleep can shape your dreams

Moheb Costandi

LISTENING to an audiobook before bed affects a person's brain activity after they nod off as well as the content of their dreams. Better understanding this effect could lead to therapies to help treat certain mental health conditions by targeting memory processing during sleep.

When we sleep, our brain spontaneously "replays", or reactivates, patterns of electrical activity that are related to learning to transfer important new information to long-term memory storage. It has been suggested that dreams may reflect this reactivation, but exactly how is unclear.

To investigate, Deniz Kumral at the University of Freiburg, Germany, and her colleagues asked 20 people to listen to different audiobooks just before they went to sleep. These included *The Mystery of the Blue Train* by Agatha Christie and



ANDRIILYSENKO/GETTY IMAGES

When people slumber, their brains replay patterns of activity that may help them form long-term memories

Inkheart by Cornelia Funke.

Among the participants who remembered their dreams, the researchers could identify which audiobook each had heard from their descriptions of the dreams.

While the participants slept, the researchers also used an EEG cap that detects electrical activity to

record their brain waves. This showed that the wave patterns during the rapid eye movement phase of sleep, when dreams occur, were more similar between those who had heard the same audiobook than those who had heard different ones, suggesting that the listening experience shaped the brain activity.

Further analysis of the patterns revealed that high-frequency beta waves – between 18 and 30 hertz – were most strongly associated with the participants recalling the audiobook-related content of their dreams (bioRxiv, doi.org/kn43).

The findings suggest that daily life experiences can shape dream content via memory reactivation, according to the researchers. But while dreaming may serve a distinct purpose in memory formation, it could also be a by-product of memory processing.

"Daytime experiences are rarely replayed as experienced, but are

almost always modified or surface in different contexts," says Kumral. "This fits with the idea that reactivation and dreaming are related to consolidation of memory, in the sense that new experiences are integrated

"Daytime experiences are almost always modified in dreams or surface in different contexts"

with existing knowledge."

The study lays the groundwork for future research that could have medical applications, she says.

"Individuals with certain psychological or psychiatric conditions might benefit from tailored strategies that enhance memory processing or treat disorders of dreaming during sleep, potentially contributing to improved cognitive and emotional well-being," says Kumral. ■

Planetary science

Mars used to have wet seasons similar to those on Earth

ANCIENT Mars had alternating wet and dry seasons, according to mud patterns discovered by NASA's Curiosity rover. These cycles may have helped form some of the building blocks for life.

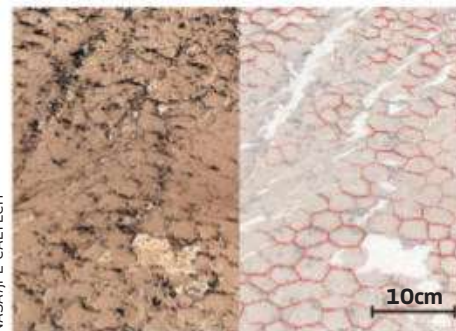
There is evidence Mars once had liquid water in lakes and rivers, but it was unclear whether it came from one-off events, such as volcanoes melting ice, or whether it was tied to a weather cycle.

Now, William Rapin at the University of Toulouse, France, and his colleagues have examined images from Curiosity and found a distinctive pattern of hexagonal

ridges (see image, right) in Gale crater, a former lake, which they say can only be formed from repeated wet and dry environments, each lasting about a Martian year or less.

"It's the first time we can show that the climate sustained hydrological change seasonally, or [had] wet and dry seasons," says Rapin. "We knew the Earth had them, but we didn't know of any other planets that did. Now we know Mars had seasons."

The researchers think the ridges were originally cracks in dried mud. The cracks, which tend to intersect at specific angles, would have been filled in by minerals. As material was washed away by water, this more resilient mix of mud and rock in the cracks would have remained, forming the ridges. "Only a seasonal



NASA/JPL-CALTECH

climate – something with high frequency, geologically speaking – can produce those cracks in the mud that got fossilised," says Rapin.

The hexagons are about 4 centimetres wide, which the researchers say means the water was about 2 centimetres deep. This suggests these cycles were regular, lasting around a Martian year, and may have persisted for millions of years (*Nature*, doi.org/gsknc7).

The Curiosity rover has spotted hexagonal shapes in Gale crater on Mars

Dry lakes on Earth that fill with water in rainy seasons display similar patterns.

The Martian markings seem about 3.6 billion years old. This is around the time we know life emerged on Earth. "If you have life on Earth, then why not life on Mars, if conditions on both planets were about the same," says Mark Sephton at Imperial College London.

The seasonal weather could also have helped form molecules essential for life, such as RNA, because the chemical reactions needed, like polymerisation, often require periods of dehydration. ■
Alex Wilkins

Analysis Dietary guidance

Ultra-processed foods get a bad rap – is it backed by science?

The relationship between processed foods and health isn't clear, and eating such foods may sometimes be beneficial, finds **Grace Wade**



GOODMOMENTS/SHUTTERSTOCK

COMMON dietary advice encourages us to eat whole foods and avoid processed ones. But there is no clear understanding of what makes a food ultra-processed or how these foods affect our health. Broadly labelling ultra-processed foods as bad could not only lead us to overlook other potential factors contributing to obesity, but may create a new set of unintended health consequences.

For decades, public health experts have raised the alarm about ultra-processed foods, blaming them for global increases in obesity, diabetes and heart disease. Already, two countries – Canada and Brazil – have advice on avoiding ultra-processed foods in their national dietary guidelines. More countries, including the US and Australia, are debating whether to follow suit.

However, there are too many unknowns to justify such sweeping recommendations, according to a panel of nutrition researchers at a conference hosted by the American Society for Nutrition in Boston on 23 July.

Despite the oft-repeated message that ultra-processed foods are bad for us, there is no universal definition of such products. The most widely used

description is based on the NOVA food classification system, which says a food is ultra-processed if it uses ingredients, often derived from other foods, to “imitate or enhance the sensory qualities of foods or to disguise unpalatable aspects of the final product”. NOVA also states that “a multitude of sequences or processes is used

86

Diet quality score (out of 100) for one ultra-processed menu

to combine the usually many ingredients” and these processes can't be done at home.

This definition is broad and unclear, says Lauren O'Connor at the US Department of Agriculture (USDA), who participated in the panel. As such, it can be difficult to classify foods according to the NOVA system, especially in countries like the US where most foods undergo some form of processing, she says.

What's more, it is hard to be sure how – or if – ultra-processed foods are detrimental to health. For instance, research suggests that a diet rich in foods that are often classified as ultra-processed is associated with an elevated risk

Some ultra-processed foods, such as yogurt, have important nutrients

of developing obesity. But “we don't know the causal factor, if there is one at all”, says O'Connor. Without a clear definition of “ultra-processed”, it is challenging to investigate what it is about these foods that may be harming health.

Lumping foods together like this also fails to capture the nuanced effects some of them have on health. Research shows that foods often classified as ultra-processed can contribute key nutrients to people's diets. Earlier this year, O'Connor and her colleagues showed that, of 1140 children aged between 6 and 23 months old in the US, 75 per cent of their iron intake and 48 per cent of their zinc intake, on average, came from foods deemed ultra-processed by NOVA. “One of the biggest benefits of some ultra-processed foods is the fortification of micronutrients,” says O'Connor.

This means blanket guidance to avoid ultra-processed foods could lead to nutrient deficiencies, says Julie Jones at St. Catherine University in Minnesota, also part of the panel.

Ultra-processed food can form part of a healthy diet, she says. For instance, Julie Hess at the USDA and her colleagues recently constructed a seven-day menu where 91 per cent of calories came from ultra-processed foods and found it had a diet quality score of 86 out of 100. By comparison, the average US diet has a score of 58.

“There is still a lot that we don't know about ultra-processed foods,” says O'Connor. “We have to be really mindful of that because we don't want to stigmatise any foods.” ■

Zoology

Female stick insect clones itself despite sex with males

Carissa Wong

EVEN if they have sex with males, females of a Japanese stick insect species produce offspring that are genetically identical to themselves.

The females of some stick insect species, including one from Japan called *Ramulus mikado*, have evolved to produce eggs that can turn into female embryos without requiring fertilisation by sperm. This process – parthenogenesis – means males gradually get less common.



SAIGLOBAL/NT/SHUTTERSTOCK

Japanese stick insects lay eggs that develop into clones of the mother

Males of other parthenogenetic species mate with females, giving rise to offspring that inherit DNA from both parents. To find out if this happens in *R. mikado*, Tomonari Nozaki at the National Institute for Basic Biology in Japan and his colleagues collected 15 females and four of the very rare males from the wild. They placed the males with females and verified that all males were able to mount and insert their penis into females.

Then, the researchers sequenced the DNA of eggs subsequently laid by females and compared this with the genetic sequences of the males and females that mated. All eggs were female clones of their mothers. When Nozaki and his colleagues analysed the testes of one male, they saw that the sperm were defective. The species may have lost the ability to reproduce sexually, the researchers write (bioRxiv, doi.org/kpfd).

Females may produce some males via parthenogenesis, but the exact mechanism here is unknown, says Alexander Brandt at the University of Lausanne in Switzerland. ■

Space

Russia chases former Soviet glory

First lunar mission in nearly 50 years is viewed as attempt to show the country can still compete

Leah Crane

RUSSIA has launched its first moon mission in nearly 50 years. It is being viewed as important for the country's space industry – which has been in decline for decades – and a push by Russia to regain the power and importance on the global stage it once had as part of the Soviet Union.

The Luna 25 mission launched on 11 August from the Vostochny Cosmodrome. It consists of a lander with scientific instruments designed largely to study the make-up and properties of moon dust, and it is intended to land about 11 days after launch.

The mission's name links it directly to the space missions of the Soviet Union: Luna 24, this mission's predecessor, took place in 1976. Luna 25 is, in many ways, similar to Luna 24, but rather than landing in the moon's equatorial region as previous Luna landers did, it is intended to land near the moon's south pole, an area of interest for human exploration because of its water reservoirs.

After Luna 24, the booming Soviet space industry began to fade along with the last vestiges

of the cold war's space race. The collapse of the Soviet Union 32 years ago meant that Russia had to launch a new space agency, Roscosmos, which has suffered from political chaos and funding issues. In recent decades, many other players have joined the crowd operating in space and there is a new space race going on.

"It seems like this is something about 'Make Russia Great Again'.

Luna 25 took off from Vostochny Cosmodrome in Russia on 11 August



ROSCOSMOS STATE SPACE CORP/EPFL-EFE/SHUTTERSTOCK

It's about reclaiming territory that the Soviet Union had and reaching for some of that former glory," says Andrew Jenks at California State University, Long Beach. "There's an awful lot riding on this launch, in terms of whether Russia has the right stuff on the international stage to show that it can compete in an area where it had once been a clear leader."

Since the 1970s, the Soviet and then Russian space programmes have experienced a string of high-profile failures: a series of rocket explosions, a space shuttle that

only launched once and a planned Mars mission that never made it beyond Earth's orbit.

That record discourages some in the space-flight industry from being optimistic about Luna 25. "I hope they succeed, but the more likely result if you're a betting person would be failure," says Jenks. "The failures in the space programme have been almost continuous."

If it does succeed, it will be a major milestone for Russia, setting the stage for an eventual permanent moon base in collaboration with China. It could also reinvigorate Russia's ailing space sector, which has been affected by "brain drain" and a loss of international partnerships due to the war in Ukraine.

"I think this would be a real morale booster for the thousands of people who make up the infrastructure of Russian space science," says Jenks. But he doesn't think that one successful mission will be enough to turn around the Russian space industry.

Roscosmos didn't respond to a request for comment. ■

Health

Blood test could aid the diagnosis of 52 medical conditions

MEASURING proteins that circulate in the blood could enable earlier diagnosis of dozens of medical conditions, including cancer, heart disease and motor neuron disease.

Researchers have previously used blood protein levels to identify people at high risk of a narrow range of common conditions, such as diabetes and heart disease.

Claudia Langenberg at the University of Cambridge and her

colleagues wanted to see if this approach is any better than existing clinical models that rely on basic information – such as age and weight – and data from common blood tests, which look at blood cells and about a dozen proteins.

So they turned to health records and data on roughly 3000 proteins found in blood, collected from more than 41,000 people.

Using information from around 70 per cent of the participants, the researchers built statistical models that predict the risk of developing a range of conditions within a 10-year follow-up period. By

testing the models on the remaining 30 per cent of participants, the researchers found that combining the protein-based model with the standard clinical models allowed them to pinpoint the risk of developing 52 medical conditions.

The researchers identified some 70 per cent of the participants who went on to develop dilated cardiomyopathy and pulmonary fibrosis. In contrast, the clinical

"The method identified 70 per cent of the people who went on to develop dilated cardiomyopathy"

models alone identified roughly 30 per cent.

The combined approach also identified more than twice as many people who went on to develop bone marrow cancer and motor neuron disease than clinical models alone (medRxiv, doi.org/kn7g).

Combining the two methods incorrectly classed people as being at high risk for a particular condition 10 per cent of the time, however. Despite this, the researchers say the blood tests could allow earlier detection and treatment for many medical conditions. ■

Carissa Wong

Zoology

Young spiders can turn cannibal and eat their siblings

Alice Klein

BABY cupboard spiders that can't find enough food devour each other.

Cannibalism has been observed in several spider species, but typically involves adult females eating males during or after sex.

Now, Jeffrey Harvey at the Netherlands Institute of Ecology and his colleagues have discovered that a species called *Steatoda grossa* engages in a different kind of



Newly hatched cupboard spiders by the nest they emerged from

cannibalism. The species, which lives in countries including the UK, US and Australia, is more commonly known as the cupboard spider, brown house spider or false widow.

Newly hatched spiderlings typically stay in their mother's web for several weeks before going out on their own. Harvey and his colleagues kept 10 groups of spiderling siblings in Petri dishes and fed them freshly killed flies once a week, every three weeks or not at all. The researchers measured the rate of cannibalism by counting how many were left per dish until only one remained because it had eaten all its siblings.

Spiderlings with no food were the fastest to eat their siblings and those fed every week were the slowest (*Ethology*, doi.org/kn5h). This suggests they must reach a certain level of hunger before attacking their siblings, says Harvey.

He believes such cannibalism is rife in our homes because "if [the spiderlings] are living in a cupboard or a closed space, they're not going to be able to disperse very far, and their sources of food, like flies, are going to be hard to find". ■

Evolution

Ocean bacteria may be closest relatives of mitochondria

Jason Arunn Murugesu

MARINE bacteria found in hot springs may be the closest living relatives of the ancient bacteria that transformed into mitochondria more than a billion years ago.

Mitochondria are structures found in all cells with a nucleus, also known as eukaryotes, and play a key role in producing energy to power the cell and thus larger multicellular organisms like us. They are thought to have evolved between about 1.6 billion and 1.8 billion years ago from a type of alphaproteobacteria – one of the most abundant groups of bacteria on Earth.

But we still don't know which specific bacterium was engulfed by another cell, formed a symbiotic relationship with its host and eventually developed into mitochondria, says Otto Geiger at the National Autonomous University of Mexico.

To narrow down the

Mitochondria (blue/green) are found inside our cells, but their ancestors were free-living bacteria

potential suspects, Geiger and his colleagues surveyed all known genomes of alphaproteobacteria species on Earth today to identify those with traits most similar to those that they think belonged to the so-called proto-mitochondria.

The analysis involved surveying thousands of genomes and matching them against dozens of criteria, says Geiger. One of the key

"The bacteria that became mitochondria and their original host are likely to have lived in hot springs"

criterion was the ability of the bacteria to produce two sorts of compounds called lipids, which are essential to mitochondria functioning, says Geiger.

The first type of these lipids, called ceramide, isn't typically found in bacteria but is produced in mitochondria. Along with the other key lipid, cardiolipin, it is involved in respiration and energy production in mitochondria.

The presence of genes to produce both lipids is important

because together they also play a vital role in helping to signal that mitochondria in eukaryotes are damaged and need to be removed. This function is conserved in all eukaryotes, says Geiger, which suggests that the proto-mitochondria also possessed genes to produce both lipids.

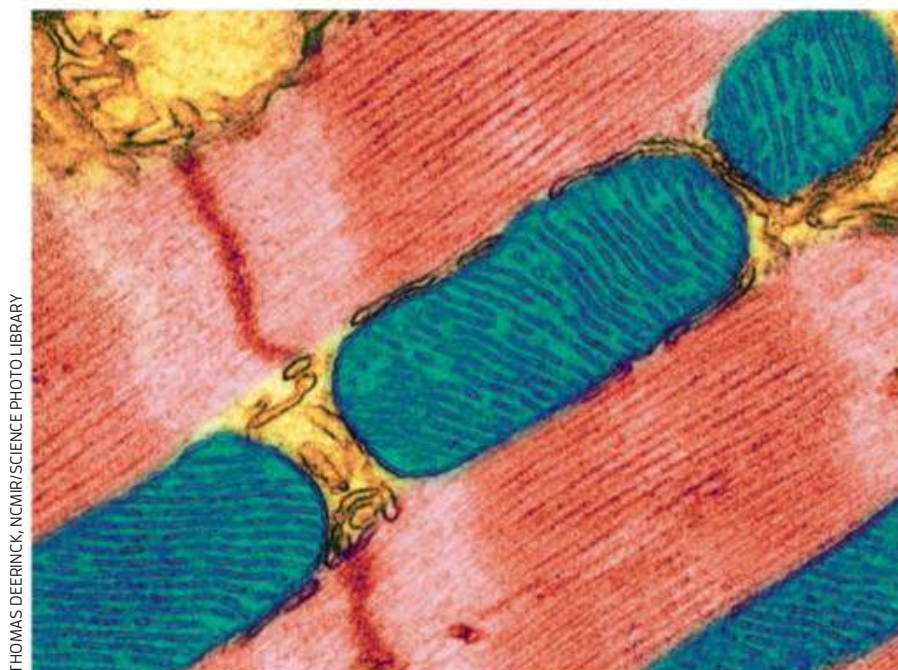
The researchers concluded that marine bacteria found in hot springs in seas and oceans around the world had the traits most associated with the proto-mitochondria (*Science Advances*, doi.org/kn4z).

The bacteria have previously been found in the Karmadon springs in Russia and Geiger says they can be found in Mexico, too. These bacteria, belonging to the Iodidimonadales order, especially those in the *Iodidimonas* genus, are a good candidate because they are found only in locations with a high oxygen gradient, says Geiger.

"These bacteria really depend on oxygen," he says, in the same way that mitochondria do to produce energy. He adds that the original host of the proto-mitochondria, which ultimately evolved alongside the proto-mitochondria to produce eukaryotes, is also likely to have lived in hot springs.

Geiger says this study isn't the final word, however. "If we had done this study in 2015, we wouldn't have been able to identify these bacteria because these bacteria had never been isolated before 2016," he says.

"I would not be surprised if in three, five or 10 years there is another candidate which is even closer to what we think could be the proto-mitochondria," says Geiger. ■



THOMAS DEERINCK, NCMIP/SCIENCE PHOTO LIBRARY

Space

Brown dwarf has a tiny 2-hour orbit

A SMALL star and its companion, a “failed star” known as a brown dwarf, are locked in an incredibly tight orbit, rotating in a volume smaller than the sun.

Kareem El-Badry at the California Institute of Technology and his colleagues have found a brown dwarf, called ZTF J2020+5033, that orbits a star roughly every 2 hours, the tightest known orbit for two uncollapsed stars (arXiv, doi.org/kn54).

Eventually, in a few tens of millions of years, ZTF J2020+5033 will become close enough to its partner star that it will begin to lose material to it, due to its low density.

This could lead to a massive explosion, or the two could merge to form a new star. Either way, there would no longer be a brown dwarf. **Alex Wilkins**



CHARLIE HAMILTON-JAMES/NATUREPL.COM

Zoology

Crocodiles can tell when human babies are distressed

CROCODILES are so attuned to the cries of young great apes that they may recognise their distress better than we do.

Nicolas Grimault at the University of Lyon in France and his team used the recorded cries of 24 hominid infants – including 12 humans (*Homo sapiens*), six captive bonobos (*Pan paniscus*) and six wild chimpanzees (*Pan troglodytes*).

The bonobo and chimp infants were crying at varying levels of distress in circumstances such as when distant from their mother. The human infants were crying either during bath time at home, or during vaccination at a health centre. The researchers ran analyses on each sound file to identify which acoustic

variables were associated with different levels of distress.

They played the recordings via speakers at four ponds in Crocoparc zoo, Morocco, after it had closed. Each pond hosted up to 25 adult male and female Nile crocodiles (*Crocodylus niloticus*, pictured).

The reptiles responded to the cries from all three species by turning their heads, swimming towards the sound and sometimes even biting the speakers. Their reactions were stronger when the recordings had sound irregularities such as vocal roughness caused by going beyond the normal range of vocal cords – and more energy in high frequencies (*Proceedings of the Royal Society B*, doi.org/kn6b). These traits are linked with higher emotional arousal, says Grimault.

By contrast, humans assess distress based on pitch, which crocodiles seem to ignore, so humans can mistake the distress level of infants of species with high-pitched cries, such as bonobos, he says. **Christa Lesté-Lasserre**

Really brief



MICHAEL WHEATLEY/ALAMY

US plans biggest survey of nature

In an effort to better protect its biodiversity, the US is launching the National Nature Assessment. Due to be completed in 2026, it will be the largest survey of water, land and wildlife in the nation and should help researchers and lawmakers determine how to preserve habitats and species.

Plastic bags can be recycled into soap

Two types of common plastic can be melted down and turned into the fatty acids that are used to make soaps and detergents. The technique works on polyethylene, used in shopping bags and bottles, and polypropylene, found in coffee cups and food packaging (*Science*, doi.org/kn6x).

Video-game time limits didn't work

The tough restrictions that China imposed on how long under-18s can spend playing video games from 1 November 2019 had no effect on heavy gaming generally in the first 11 weeks after the rule came in, according to a study of 7 billion hours of playing time (*Nature Human Behaviour*, doi.org/kn66).

Health

Vaccine for 'mono' shows promise

A VACCINE that fends off the Epstein-Barr virus (EBV) has had positive results in mice. The virus causes glandular fever, also known as infectious mononucleosis or “mono”, and has been linked to multiple sclerosis and various cancers including lymphoma.

Rajiv Khanna at the Berghofer Medical Research Institute in Australia and his colleagues have designed a vaccine that produces antibodies against the virus, as well as triggering a type of immune cell, called T-cells, to destroy cells that EBV is multiplying within. In mice, the vaccine produced EBV antibodies and T-cells for more than seven months after immunisation. It also stopped the growth of tumours in mice that were induced to develop lymphoma (*Nature Communications*, doi.org/kn6j). **Chen Ly**

The Future of Food and Agriculture at
New Scientist Live is brought to you by:



Feature partner

New
Scientist
Live

7 - 8 OCTOBER
SCHOOLS' DAY 9 OCTOBER
EXCEL LONDON AND ONLINE

newscientist.com/nsi

A D V E R T O R I A L

How the humble wheat plant is at the leading edge of technology

It's estimated that humans first domesticated wheat over 10,000 years ago, as ancient farmers selected wild grasses for larger grain sizes. Since then, wheat has become a staple food for much of the world's population, grown on more of Earth's land area than any other food crop.

However, even though wheat has been around for millennia, scientists are still harnessing the latest technology to improve crops even further. For example, most seeds sold to farmers are just crossbred older varieties, that are then repeatedly grown and harvested to produce a uniform seed line. However, true hybrid seeds (F1) grow more vigorously than either parent.

"Some agricultural crops are true hybrid crops, so the farmer actually plants out the F1 seed" said Nicholas Bird, Research Lead for winter wheat in the UK for KWS, a leading seed supplier.

"The cost of production is the thing that's stopping hybrid wheat from entering the market. But that's something we're working on."

But that's not all. When asked about what other technology will have a disruptive effect on the science of wheat, Nicholas had one answer: "High throughput phenotyping". Using drones, imaging systems and machine learning, traits in plants can be rapidly identified.

"At the moment if we want to phenotype a plant, we have to visually look at it, and there's only so many you can look at in a day.

Whereas we can image fields on a pixel-by-pixel basis, we can identify a particular plant that's got no disease or one that's full of disease. And then we can image lots more plots and lines and pick the ones that are certainly disease resistant."

You can find out more by checking out our 'Future of Food and Agriculture' feature at New Scientist Live this October. The show is open to the public on the weekend of 7/8 October and to schools on Monday 9 October. **Find out more at:** newscientist.com/future-of-agriculture

Lead
education
partner:



NAZAR RYBAKI/ISTOCK

The columnist
Chanda Prescod-Weinstein on Isaac Newton's laws **p22**

Aperture
Farming seagrass to protect ocean ecosystems **p24**

Culture
Why we should study how we grow from embryos **p26**

Culture columnist
Sally Adee on *Bridge*, the latest pick for our book club **p28**

Letters
The real cause of obesity has yet to be confronted **p30**

Comment

Unnatural disasters

Knowing how climate change contributes to extreme weather means we can hold countries and companies to account, says **Friederike Otto**

MEDIA reporting on the role of climate change in extreme weather events used to be framed somewhere along the lines of: "Although this is the kind of phenomenon that global warming makes more frequent, we can't attribute individual weather events to climate change." This was correct in the 20th century, but it is definitely wrong today.

The first study to attribute an individual extreme event, the 2003 European summer heatwave, to climate change was published in 2004. Many followed. More than 50 are from World Weather Attribution, an initiative of climate scientists I co-founded in 2015 that studies events like extreme rainfall, heatwaves and droughts to assess whether human-induced climate change made them more likely and intense.

Last year, our study found that monsoons in Pakistan that led to flooding, at least 1500 deaths and over \$30 billion in damages was made up to 75 per cent more intense by climate change. The extreme heat hitting southern Europe and parts of North America this summer also wouldn't have occurred without climate change. Studies like these form a major new line of evidence in the most recent Intergovernmental Panel on Climate Change reports, showing human-caused climate change "is already affecting many weather and climate extremes in every region".

Attribution science can also evidence the unequal impacts of



MICHELLE D'URBANO

climate change. The extreme weather it intensifies is inflicting enormous damage on the world's poorest, who overwhelmingly live in the Global South (lower-income, often decolonised nations mainly in the south of the world) and have contributed least to emissions.

Why is this important? Why do we not only need to know that heatwaves will become more frequent with global warming, but also how much angrier a particular weather event has become? It is because this lets us connect theoretical understanding with concrete losses and experience, and thus

to take huge steps forwards in climate policy and litigation.

We can measure the amount of greenhouse gases that human activities have added to the atmosphere since the start of the industrial revolution. We also have databases compiling the amount of carbon dioxide emissions linked to fossil fuel companies and countries. Now, we know how much more intense a storm is and how much of the damages are attributable to human-induced climate change.

It is no coincidence that the COP27 climate conference last year finally decided to set up a fund to

support vulnerable nations with losses and damages from climate change, or that Multnomah county in Oregon is now suing fossil fuel firms for over \$50 billion in damages that occurred during an extreme heatwave in 2021.

As well as providing evidence to hold countries and companies accountable for their inaction on climate change, individual attribution studies also highlight how communities can become more resilient to increased extreme weather in the future.

Every study we have done has found that suffering and disasters resulted from people's exposure to extreme weather because they needed to earn money and had no alternative income sources, lacked information about how to react to an extreme weather alert, lived in poor quality housing and more. In short, their exposure was down to existing vulnerabilities and overstretched or non-existent social systems.

While climate change often made hazards worse, many of the worst impacts could have been prevented. This might sound dire, but in fact it gives us a lot of agency to make the world better. We need to keep fighting to stop burning fossil fuels, but there are also many lives to be saved by improving the quality of life for all. ■



Friederike Otto is a climatologist at Imperial College London and author of *Angry Weather*

Field notes from space-time

It's all relative The apparent equivalence of gravitational mass to inertial mass is a beautiful feature of the cosmos, with a deep implication, says **Chanda Prescod-Weinstein**



Chanda Prescod-Weinstein is an associate professor of physics and astronomy, and a core faculty member in women's studies at the University of New Hampshire. Her research in theoretical physics focuses on cosmology, neutron stars and particles beyond the standard model

Chanda's week

What I'm reading

Legally blind Star Trek actor Bruce Horak recommended *There Plant Eyes: A personal and cultural history of blindness* by M. Leona Godin, and I'm looking forward to digging in.

What I'm watching

I'm just back from a Star Trek convention, so a lot of Trek to stay connected with the wonderful feeling of that space.

What I'm working on

I'm trying to keep track of all of the amazing labour actions happening – so proud to be a union member right now!

This column appears monthly. Up next week: Graham Lawton

THERE are two kinds of theoretical physicists: those who use the correct equation for calculating distances in space-time, and those who don't.

Obviously, I'm being a bit tongue in cheek here, but I'm serious when I say there is a real bifurcation. The two formulations of this equation for distance – what we call the metric – are equivalent and when used correctly will give the same answers for all calculations. But each group has reasons for believing that one is more natural than the other. Particle physicists tend to use one; relativists (people trained in general relativity) tend to use the other. I'm among the group of particle physicists who use the one favoured by relativists, and this is for two reasons: it is better, and I trained as a relativist.

These differences in how scientific groups approach the same scientific question aren't often obvious to outsiders. It was on my mind when I got a letter from a *New Scientist* reader who had seen my June column, about the problem of defining mass and explaining its presence. I wrote it very much from the perspective of particle physics, describing the Higgs-Englert-Brout mechanism, which explains how most other particles in the standard model of particle physics gain mass.

But the astute reader pointed out that I had sidestepped a whole other side to the question of mass that pre-dates the advent of the quantum field theories, a calculational framework that merges special relativity with quantum mechanics in order to describe particle physics.

I admit to being caught red-handed and showing my bias towards how particle physics approaches the question of mass, which is to use quantum field

theories to try to explain where it comes from. My transition from graduate student relativist to professor of particle physics feels complete, but just as some might feel my perspective on the space-time metric is incomplete, so too is a single-sided discussion of the physical meaning of mass in physics.

So let us return to a simpler time, before the advent of quantum mechanics, to Newton's laws, which describe some basic properties of forces. Isaac Newton's most famous contribution to physics is likely to be his second law, $F = ma$, which states that any

“A letter from a reader showed my bias towards how particle physics approaches the question of mass”

force (F) an object is experiencing is equal to its acceleration (a) multiplied by its mass (m).

Today we know there are four fundamental forces: the strong nuclear force, the weak nuclear force, the electromagnetic force and the gravitational force. Newton gave a mathematical form to the weakest one, gravity. His law of gravitation posited that massive objects were attracted to each other, and the strength of the force of that attraction was proportional to the mass of both objects.

One of the first things students in high school physics learn is that one can set the equation in Newton's second law equal to the one in his law of gravitation, which means that we can say the force in his law of gravitation is equal to the force that appears in $F = ma$.

In principle, the mass of the object being described appears twice in such a description: on

both sides of the equal sign, once on the law of gravitation side and once on the second law side. But this raises an interesting question: are these in fact the same mass?

The one that appears in Newton's law of gravitation is known as the gravitational mass, while the one that appears in his second law is known as inertial mass because it describes how resistant the object is to a force that is applied to it – giving a sense of how much inertia against motion it has.

The apparent equivalence of gravitational mass to inertial mass is a remarkable and beautiful feature of the cosmos with a deep implication: mass is mass, regardless of an object's structure. That is to say, there is no way for gravity to know what the object is made of. The mass of a halo of dark matter particles looks the same to gravity as the mass of a black hole. The structure of an object makes no difference to the law of gravitation. This principle of equivalence eventually led Albert Einstein to the revelations that would translate into his magnificent general theory of relativity.

Today, we mostly take it for granted that gravitational and inertial mass are equivalent. But physicists aren't ones to rest on our assumptive laurels and people are still testing whether this is true, such as the Eöt-Wash group at the University of Washington. Their experiments are an example of ones where a null result is the expectation (and maybe for some, the hope). But there is always the possibility that, as the experiments become more exacting, there will be a surprise.

We take mass for granted, and tend to think of Newton's laws as rather simple. But ultimately, they still give us a lot to think about. ■

Events

NewScientist

7 - 8 OCTOBER
SCHOOLS' DAY 9 OCTOBER
EXCEL LONDON AND ONLINE

New Scientist Live

HURRY
Early bird
discount for
Sunday tickets
ends this
weekend

**Hear from 50+ amazing speakers covering the
latest in scientific discoveries across four themed stages**

THE FUTURE

Your place to discover the world of tomorrow.
From cybersecurity to digital twins, this is the
place to explore the innovations that will power the
technology of the next decades.

OUR PLANET

Home for all things environmental, from in-depth
analysis of the climate crisis to the mysteries of
the deepest oceans. We will examine everything
from lab-grown meat to the truth about female
animals, to reveal the full diversity of life on Earth.



MIND AND BODY

This stage is all about being human. From
teenage mental health to growing 'mini brains' in
a dish, from psychedelics to the psychology of
misinformation, we will reveal amazing research
to help you live a happier, healthier life.

THE UNIVERSE

Your place to hear about the mysteries of the
cosmos. Hear from world-leading scientists about
the JUICE mission to Jupiter's moons, the latest
results from the James Webb Space Telescope
and the quest to photograph a black hole.



Find out more and book your early bird tickets

newscientist.com/nsipa





Grassy haven



Photographer **Lisi Niesner**
Agency **Reuters**

THESE researchers from the GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany, are on a mission to rescue a crucial marine ecosystem that is being lost to climate change: seagrass meadows. Seagrass helps the ocean store carbon dioxide and is a key source of food and shelter for marine life, but a third of European seagrass has vanished since the 19th century.

The idea behind SeaStore – the joint seagrass restoration project involving GEOMAR – is to breed a version that is more resistant to rising sea temperatures, in the hope this will help the meadows flourish again. Flowering seagrass is collected from the Baltic Sea off northern Germany and cultivated in the lab until the seeds are ready to be harvested and planted.

So far, it has been “very successful... the plants are healthy and growing well”, says GEOMAR researcher Angela Stevenson, shown in the main image collecting seagrass. Another researcher can be seen snorkelling at top right, while the image below that is of Stevenson at a citizen diving course, where locals are being recruited and trained to help with the project. The bottom row of images shows (left to right): PhD student Isabella Provera at the lab, tubes of samples to analyse the meadows’ development, a student preparing seagrass for analysis and GEOMAR researcher Tadhg O Corcora studying samples.

GEOMAR’s Thorsten Reusch says that, despite the hype, to ensure SeaStore isn’t a “big missed opportunity”, more funding is needed to ensure the project succeeds and to get more citizens involved in ocean science. ■

Gege Li

Take a single cell

Understanding how humans and other multicellular organisms develop from embryos has big implications for the future of medicine, finds **Clare Wilson**



Book

From One Cell

Ben Stanger

W. W. Norton

“WHERE do babies come from?” isn’t just a question some parents dread hearing from their children, but also one that has perplexed philosophers since the time of Ancient Greece. For anyone today, armed with the grasp of basic biology that was lacking in our forebears, it is hard to imagine how they could have even framed the problem. Once you know something, it is hard to unknow it.

To get around that conceptual obstacle, Ben Stanger, a developmental biologist at the University of Pennsylvania, posed the question to his 6-year-old daughter, Sarah. She thought that the answer was obvious: a baby starts out as a “tiny tiny tiny baby”.

Interestingly, this idea of preformationism – that we develop from miniature, squished-up versions of our later selves – was popular for many centuries. The 17th-century Dutch microscopist Nicolaas Hartsoeker even produced a now iconic sketch of how a preformed human might be squashed into every sperm, with an outsized head tucked into diminutive knees.

Preformationism died out in the 1800s, partly thanks to a key scientific leap: cell theory, the principle that the cell is the basic unit of life, much as atoms are the building blocks of matter. Babies start life from a single cell – as do nearly all multicellular organisms, from meerkats to marigolds to mushrooms.

But that discovery only ended up creating a deeper mystery. As Stanger puts it: “How does all the information necessary to make

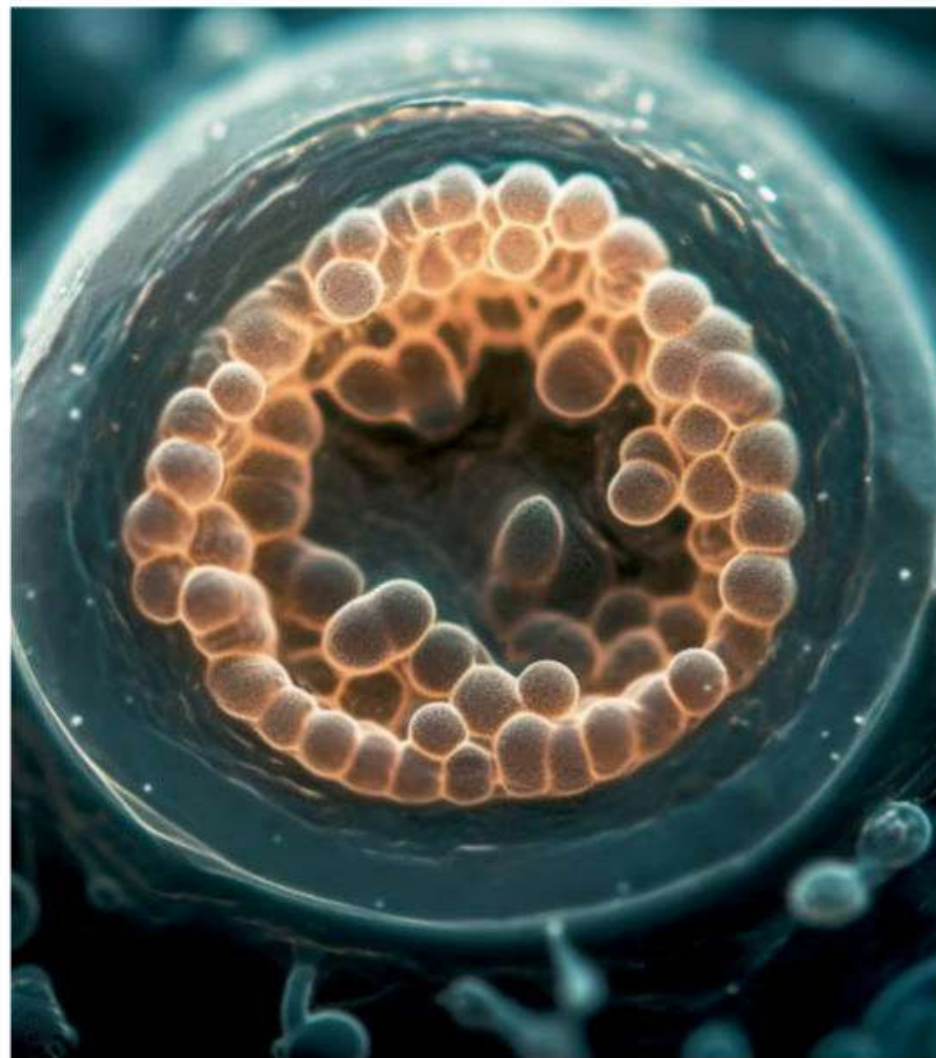


Illustration of a blastocyst, an early stage of an embryo

nature uses to construct the body are all too often the means of its undoing.”

Embryology is also a potential source of new kinds of medicine, most obviously thanks to the nascent science of stem cells, which have the ability to multiply almost indefinitely and to turn into different bodily tissues.

The early embryo can be thought of as a ball of stem cells, and this is, in fact, where these wonder cells were discovered. If we can take control of stem cells and manipulate them in the lab, we could grow new tissues and organs to help people with a wide range of medical conditions.

Stanger has a gift for original metaphors. For instance, cells “know” their position in the embryo by detecting the levels of certain chemicals, whose concentration drops off with greater distance from their source – a process he compares to the way we can tell how far we are from a mobile phone tower based on the number of bars of signal that we receive.

And then there is the impressive power of stem cells to give rise to cells of specialised tissues while also duplicating themselves, which Stanger likens to the trick of someone who is granted three wishes using their last request to ask for another three wishes.

We are a long way from understanding all the mysteries of embryonic development: in fact, you might say that we have only taken our first baby steps down this road. But in this book, the original origin story, Stanger makes a convincing case that it is a journey worth taking. ■

something so complex get compressed into something so apparently simple? How do the trillions of cells generated from this peculiar unit know what to become and where to go?”

These are the questions that Stanger explores in his book *From One Cell: A journey into life's origins and the future of medicine*. There, he covers not just our current understanding of embryology, but also the past and future of this science.

This turns out to be a fascinating tour of the major landmarks in the history of

“Cell theory establishes that the cell is the basic unit of life, much as atoms are the building blocks of matter”

biology, including the discovery of genes, the structure of DNA and the concept of messenger RNA (mRNA) – the intracellular mediator between DNA and ribosomes, the cell’s protein-making machinery.

The idea that nothing in biology makes sense except in the light of evolution has long been commonplace. But Stanger makes the case that little about the structure and functioning of adult life forms makes sense except in light of their embryonic development.

For instance, many medical conditions such as cancer, autoimmune diseases and neurodegenerative conditions are better understood thanks to a knowledge of their embryological underpinnings. As Stanger explains: “The same processes



Tiffany O'Callaghan
US Editor
New York

I moved to New York last year to help set up New Scientist's Manhattan bureau, but with lots of family and friends in the UK, we're about to return for a visit.



We'll be spending time in Northumberland in the north-east of England, where my 8-year-old and 5-year-old can't wait to visit **Alnwick Castle** – known from the *Harry Potter* films and *Robin Hood: Prince of thieves*.

They are eager to walk its ramparts, but I'm looking forward to a wander in **The Poison Garden** (pictured), part of **Alnwick Garden**. There I'll admire – from a safe distance – 100 of Earth's most dangerous plants.

While travelling, I'm also planning on listening to a few more episodes of the podcast **Wiser Than Me**. Hosted by *Seinfeld* and *Veep* actor Julia Louis-Dreyfus, it is a series of absorbing conversations with the likes of Amy Tan, Jane Fonda and Isabel Allende. Dreyfus believes older women are seldom the focus of our attention, but have a huge amount of wisdom to share. She's right, of course.

Making the data sweat

As sport becomes more competitive and more corporate, using data to find that extra edge is vital, says **Chris Stokel-Walker**



Book
Games of Edges
Bruce Schoenfeld
W. W. Norton

THE professional athletes who charge up and down playing fields for the public's entertainment in the world's biggest sports leagues seem a world away from scientists and mathematicians. At first glance, the two seem to come from different worlds with different aims, and the old stereotype of sporty teenagers stuffing their science-loving peers into school lockers endures to this day.

Yet in the past two decades, sports and science have come together in a big way. This unfolding story is told in Bruce Schoenfeld's latest book, *Game of Edges: The analytics revolution and the future of professional sports*.

This tale of how statistics has turned sports into even bigger business than it already was feels like a successor to Michael Lewis's *Moneyball*, and Schoenfeld refers

to it throughout his new book. Published in 2003, *Moneyball* looked at how the Oakland Athletics baseball team engineered success for a middling team by following the statistics and playing based on mathematical rigour, rather than sporting maxims or hunches.

But where Lewis left off with the Oakland Athletics, Schoenfeld shows a sports industry starting to recognise the power of layering analytics into all aspects of its operations, on and off the field, and of using data to find that extra edge.

This is a heavily US-focused book (understandable, given the author's nationality and self-styled status as a "baseball dad") and it privileges the national games of basketball, baseball and American football. Aside from a brief segue into soccer through the ownership of Liverpool Football Club by US businessman John W. Henry, we learn comparatively little about how this statistically led outlook can affect other sports worldwide.

For those who are interested in US sports, the overview will hold your attention. But you may find yourself drifting as you meet the fourth or fifth entrepreneur to take over a team and inject quantifiable metrics into how sport works.

We do get some of the big picture, though, as *Game of Edges* is a more business-oriented book than *Moneyball*. Where Lewis focused mainly on how Oakland Athletics extracted that extra few per cent on the field by looking beyond received wisdom and at big data, Schoenfeld reveals how this permeated the industry. We learn, for example, how introducing real-time betting during major league baseball games at the Wrigley Field stadium in Chicago, Illinois, helped improve cohesion in one club's fanbase, as those with tickets spent more time in the stadium betting, while those without still went to the betting location and soaked up the atmosphere of the game.

Game of Edges can occasionally feel like an extended case study in a Harvard MBA course – particularly as we learn how the width of seats at stadiums can help improve the fans' loyalty to a club. But there are also some truly fascinating insights.

Take the case of the Boston Red Sox baseball team, which managed to drive up ticket sales during one season by sending out physical mail to a small number of people living within a small radius of its stadium, who fitted its target audience. Bewildered by receiving a marketing message that didn't arrive via email, the fans shelled out over \$600,000 in season ticket sales from a postal campaign costing a mere \$25,000.

Schoenfeld is a canny storyteller, and his portraits of the big beasts (and the almost-rans) are vivid. I loved his outline of Will Spearman, a high-energy physicist who packed in a job at the CERN particle physics lab to work for Liverpool Football Club. He becomes the expert who knows all the data about the team's star players, yet is ignored by them in the canteen over breakfast. ■

Chris Stokel-Walker is a writer based in Newcastle upon Tyne, UK

The Boston Red Sox, pictured last month, drove up ticket sales after sending out targeted physical mail





The sci-fi column

Decisions, decisions In Lauren Beukes's *Bridge*, the eponymous lead has lost her mother, Jo, to a brain tumour. Or has she? Cryptic clues left behind for Bridge feed a thrilling tale, but also expose the big flaw in the multiverse concept, says **Sally Adee**



Sally Adee is a technology and science writer based in London. Follow her on Twitter @sally_adee



AGSANDREW/GETTY IMAGES

Who we become diverges wildly from the self we could or should have been

and by all accounts a less-than-brilliant mother. But, more than anything, she is a person who found a way to undo her own decisions, to unravel her life so she could weave it back together in the configuration that would give her everything she wanted.

But what happens when you get everything you want? In her obsessive search for the universe where she has made all the correct decisions, Jo trails a vast wake of damage. This is why *Bridge* is an essential entrant into the multiverse genre. It demonstrates the one crucial flaw in the entire multiverse fantasy: human nature.

Social scientists have identified two main cognitive styles people fall into when making decisions. Maximisers endlessly obsess over the optimal choice; satisficers simply try to do the next right thing. Sometimes, less is more. Maximisers, it turns out, take longer to agonise about their decisions, sometimes becoming too overwhelmed to make a choice at all. They are also far more likely to regret the decision they made.

Suppose you found one perfect reality. Would you be happy? Or does the existence of an infinite multiverse offer the possibility of something even better? Having infinite choices could prevent us from being happy with any option.

Bridge's chase after her mother is, by turns, a bracing meditation on what it means to make choices and entertaining cerebrotrash. Will she find the right universe? Will she find a monster that infests its host, making them obsessively seek better realities? The twists and epiphanies kept me turning every last page. ■



Book

Bridge

Lauren Beukes

Penguin Random House

Sally also recommends...

Film

Everything Everywhere All at Once

Daniel Kwan and Daniel Scheinert

If you want more of the mother-daughter multiverse, this is an intriguing outing.

Book

Self-Portrait with Nothing

Aimee Pokwatka

Tordotcom

Could there be a parallel universe in which Pepper's mother doesn't reject her? A delicate, touching story woven into a thrilling race against time.

WHICH decision was it for you? We all have that self we still hold in our mind as the one we could or should have become, its shining splendour casting a pall on the reality of how we actually turned out due to the series of haphazard choices we made before we understood their ramifications. It all started with that one decision that put us on the divergent path.

What if you could find the universe where you took the correct series of forks in the correct series of roads and everything turned out exactly how you dreamed? And what if you could take that life for yourself?

That is the premise of *Bridge*, Lauren Beukes's take on the multiverse. Bridge's mother, Jo, has contracted a brain tumour and died – or maybe Jo has been able to escape into a better version of her own life. Cryptic clues Jo left for Bridge point to this possibility, or maybe to the fact that her fatal tumour made her lose her grip on reality before she lost her life. To find out, Bridge (and her best friend Dom) must unravel a lifetime's worth of intrigue.

It wouldn't be much of a 500-page sci-fi novel if there weren't a door to another universe, so it is no spoiler to say there is. The question is why, and will Bridge follow her mother into the right one? What else is waiting there?

You will have noticed that sci-fi is currently at peak multiverse. Every other book – not to mention

“What if you could find the universe where everything turned out exactly how you dreamed?”

movie – seems to engage with this trope, now so ubiquitous that even the Marvel Cinematic Universe has inflicted it on us. Why? Possibly because the multiverse genre reflects the universality of our longing for a control group for our life choices.

There may be no better vehicle for this exploration than motherhood, famously laden with cultural baggage. Whichever choice you make, it is a one-way door. Jo is a brilliant neuroscientist,

Editor's pick

No machine will ever replace you, Annalee

5 August, p 22

From Rachel Mckeown,
Cambridge, UK

Annalee Newitz highlights the threat of AI for the creative industry and those whose livelihoods depend on it, but surely I am not the only one who can see that their personality, interests and opinions shine through in every column? It is this personal flair, also seen in features with phrases and anecdotes written in the first person, that makes such pieces far more engaging than any algorithmic output. I can imagine Annalee typing away, crafting this piece, and this is a vital part of my enjoyment as a reader.

Rest assured, Annalee, that I will never gain as much from a Newitz-themed AI generator as I do from your talent as a human writer.

The real cause of obesity has yet to be confronted

15 July, p 32

From Pauline Keyne, Beaconsfield,
Buckinghamshire, UK

I doubt I am the only one alarmed by the idea of prescribing weight-loss drugs to children, as discussed by Clare Wilson. It comes amid studies showing that a rise in consumption of ultra-processed food is linked with a decline in physical and mental health.

Manufacturers create ultra-processed foods that support over-consumption to the point where it resembles addiction. The brain changes that these anti-obesity drugs target, referred to in your article, are believed to be a consequence of this, not the cause. In other words, drugs tackle the results of damage without addressing the source.

Ultra-processed foods are now relatively cheap and regarded as normal. Poverty is one of the drivers of consumption of these substances, to the point where

they provide an estimated 60 per cent of the calories in the diets of many people. Food marketing and labelling fail to warn shoppers and sometimes add to the deception. Drugs may be seen as reasonable to reduce the harm, but making something less bad isn't the same – and isn't as worthy – as removing the cause.

We can't just preach to rainforest nations

29 July, p 26

From David Myers,
Commugny, Switzerland

Having visited Bolivia on several occasions, I found it spectacular. Moreover, as a scientist, I well understand the consequences of destroying its forests. However, I still have to question the nature of the commentary in your recent picture story on this. How can people living in higher-income countries suggest that Bolivians don't have the right to farm in their own country? Surely, if Westerners want rainforests to be undisturbed, we must provide funds and technology so that their inhabitants have alternative ways to increase their standards of living to the levels we enjoy.

Your thoughts on how to think about new AIs

29 July, p 32

From Eric Van, Watertown,
Massachusetts, US

You write that "until we know what consciousness is, there is no solid way of testing for it" in an artificial intelligence. There is, in fact, a simple way of testing for it, provided the AI is incapable of lying about itself, has colour vision and hasn't been trained on the concept of "subjective experience" and its mysteries.

You ask it: "Isn't it remarkable that when you see the colour red, you might be having a subjective experience of everyone else's green colour? And, vice versa, you could be having red experiences when seeing our green. None of us would even be aware that this swap of subjective experiences was happening!"

This is the inverted spectrum thought experiment, a staple of philosophy of mind. If the AI can't make sense of this, then it isn't conscious. If it can, it is.

From John Andreae,

Lower Hutt, New Zealand

You state: "Perhaps the relevant question isn't whether or not AIs can become conscious, but why we would want them to be conscious." If you see conscious awareness as the ability to express feelings, thoughts and intentions, then the importance of consciousness in robots that are to be useful assistants, carers or interesting companions is obvious.

From Michael Harrington,
Sydney, Australia

The consequence – or economic threat if you are personally affected – of AI is that armies of white-collar professionals, such as architects, lawyers and accountants, may become permanently redundant. You ask an AI: "Show me some designs for an east-facing beach house with a veranda and water views that backs onto a bush reserve." You scroll through a few images and floor plans, then choose one – the AI knows the location and can do a design down to the millimetre that is compliant with local rules. Any problem with the council and an AI can generate a legally perfect letter for you, as well as organise finances to your best advantage. Job done.

One person's luxury is another's necessity

22 July, p 17

From Nigel Olliver, Darwin River,
Northern Territory, Australia

I couldn't agree more with Madeleine Cuff's report regarding the carbon taxation of luxuries. However, defining a luxury is no simple matter. She mentions two examples, air travel and SUVs. Imagine three people – A, B and C – are all on the same plane travelling from a small rural town to the big city. A is on a trip to the casino, B is going to a grandchild's wedding and C is visiting the hospital for chemotherapy. The degree of luxury is different for each.

I own a four-wheel-drive vehicle. Without it, I wouldn't be able to get to the shops or a doctor's surgery during the wet season. That hardly compares with the city dweller who owns a far larger and more prestigious vehicle partly for its value as a status symbol. The difference is in the motivation of the user, not the item itself, and that is far harder to judge.

Costly space telescope is proving its worth

Letters, 22 July

From Martin Whittle, Sheffield, UK

The James Webb Space Telescope was pricey at \$10 billion, but the game-changing science that it is producing really makes it great value for money.

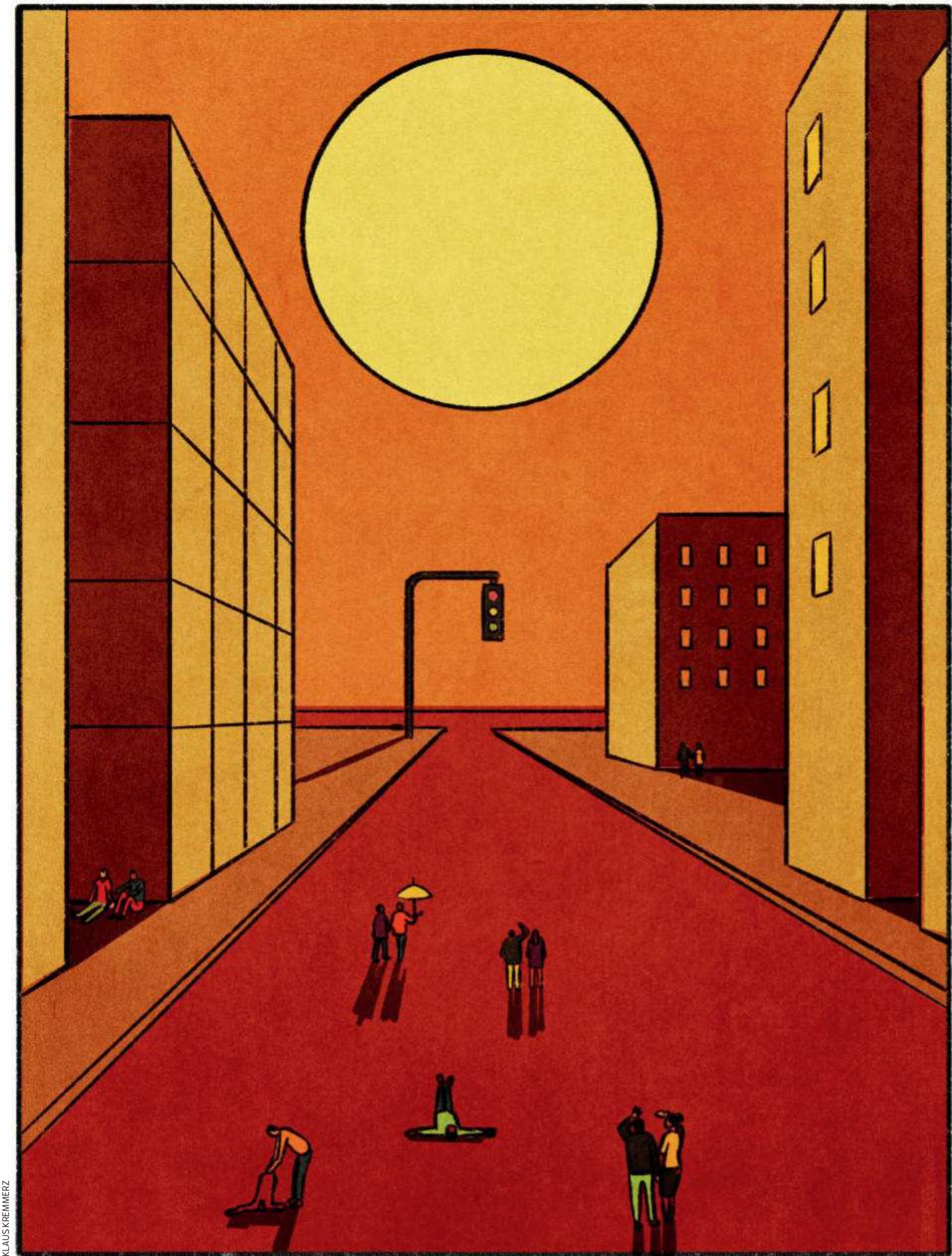
Your correspondent needs to see it in context and should save her ire for the oil companies that make huge profits by drilling for the stuff that really is destroying our environment. For example, BP profits doubled to \$28 billion last year, while Shell made record profits of \$39.9 billion. ExxonMobil shareholders were also rubbing their hands, with reported profits of \$55.7 billion. Note that \$10 billion is just 1.1 per cent of US defence spending for 2022 at \$877 billion. If JWST hadn't flown, I wonder what that money would have been spent on instead? ■



Want to get in touch?

Send letters to letters@newscientist.com;
see terms at [newscientist.com/letters](https://www.newscientist.com/letters)

Letters sent to New Scientist, 9 Derry Street,
London, W8 5HY will be delayed



KLAUS KREMMERZ

Too hot to handle?

Climate change means extreme heat will become the norm for millions of people across the world.

Graham Lawton joins an expedition in Saudi Arabia to find out how humans will respond

TRUDGING through hot, red sand is hard work, especially in temperatures above 40°C (104°F). After about 40 minutes, I am drenched, dehydrated and drained. I can't imagine doing this for 40 days, dragging all my gear behind me – including 40 litres of water, enough for five days – on a two-wheeled trolley. But that is exactly what the people I am travelling with have just done.

I am in the Nafud desert, a vast tract of sandy and rocky wilderness in northern Saudi Arabia, to experience levels of heat that I am not built to endure – and to meet 20 people participating in an expedition called Deep Climate, dedicated to understanding how humans respond to extreme conditions. “The idea is to study how human beings can adapt to a new kind of environment,” says Christian Clot, the leader of the expedition and director of the Human Adaptation Institute in France.

As the climate warms, the issue is becoming increasingly pressing. Even under the most optimistic scenarios, the scorching heat seen in southern Europe and across the US over the past couple of months, with temperatures exceeding 40°C (see page 8), will become the norm in many parts of the world.

That means the question of what happens to our brains and bodies, and the extent to which

human physiology can cope with extreme heat, matters for millions of people. “You’re going to see a great big swathe of very densely populated areas go up to unprecedented temperatures that nobody experienced in the historical climate,” says Tim Lenton at the University of Exeter, UK, who recently co-authored a research paper called “Quantifying the human cost of global warming”.

“Can we adapt to and accept new climate conditions?” asks Clot. “We don’t know. We need to learn more.” The Deep Climate expedition is the first large-scale experiment to attempt to find out.

Like every other living thing, humans evolved to have an ideal climate niche – an average temperature and rainfall range in which we can live comfortably. “The climate niche describes where people flourish and have flourished for centuries, if not millennia,” says Lenton. Technologies such as clothing, buildings, heating and air conditioning have extended that niche and allowed people to live in some of the hottest and coldest places on Earth, but they haven’t fundamentally changed our biology. The ideal mean temperature for us over the long run is around 12°C (54°F), says Lenton. Which explains why, historically, population density peaks in

locations with that mean temperature and falls off rapidly on either side.

Climate change has already altered the geographical distribution of that niche. At current levels of warming, roughly 1.1°C above pre-industrial average temperatures, some areas of Earth that were once close to the niche have been pushed further away from it. “Already, we estimate that some people have been shifted from what was the kind of climate that supported high-density populations in the past to a climate that historically would support lower density,” says Lenton.

I can tell you from experience that constant heat is extremely testing. The average temperature in Saudi Arabia during the summer, when I visited, is around 30°C (86°F), peaking at 45°C in the early afternoon and dropping into the 20s (70s) at night. It is brutal and sapping. Sleep is elusive, exertion is incredibly challenging. I found myself prostrate in my tent, fantasising about cold beer, air conditioning and swimming pools. And that was dry heat, which we know to be easier to cope with than humid heat.

It is already well-established how human bodies respond in the short term to extreme high temperatures. The initial symptoms are heat rash and cramps, caused by lost fluids and salts, which can progress to heatstroke: a fast, strong pulse, headaches, dizziness, nausea and confusion. “This is a true medical emergency,” says Bradley Uren at the University of Michigan. And the more humid it is, the lower the temperature required to get there. At around 45°C (113°F) and up to 20 per cent humidity, the human body can cool itself through sweating. But above 40 per cent humidity, 45°C can be deadly.

Extreme conditions

What we know almost nothing about is whether humans can adapt to such conditions in the long term. Enter Clot. In 2016, he realised that there was very little data on how humans will cope with future climates and came up with the idea for his experiment. To begin with, he volunteered himself as a human guinea pig and undertook three 40-day solo expeditions in the extreme climates he thought were most relevant: humid heat in the Brazilian Amazon, freezing cold in Siberia and dry heat in Iran. Every day, he took scientific readings on himself.

Clot’s solo efforts became the pilot project for the Deep Climate expedition. In 2017, the project advertised for volunteers aged ➤

between 25 and 50 who were fit, spoke French and were prepared to tolerate tough conditions. They whittled the applicants down to about 30.

There were to be three legs of the experiment, each lasting 40 days and 40 nights: humid heat, extreme cold (which will also become more common as the climate changes) and dry heat. Each leg features a team of 20 “climatonauts” picked from the original 30: 10 women and 10 men, including Clot. There is no motorised transport and everything they need has to be hauled or carried, up to 200 kilograms per person.

The locations have changed due to political instability – French Guyana in place of Brazil, Lapland for Siberia and Saudi Arabia for Iran – but the goal is the same. “We study all the processes of adaptation, and the mechanisms in the brain and in the body, to understand how we can adapt,” says Clot. By adaptation, he doesn’t mean some kind of rapid evolutionary response, rather, he is talking more broadly about how our bodies and brains react, whether that is to cope or otherwise, and how people behave in such extreme conditions.

The French Guyana expedition was completed in January, while the Lapland leg finished in April. The Saudi Arabian experiment began in early May at a village called Sakaka, 210 kilometres as the crow flies from the finishing line at Jubbah, an oasis town on the edge of the King Salman bin Abdulaziz Royal Reserve. The climatonauts walked up to 10 kilometres a day, hauling their gear over dunes and rocks and running the gauntlet of scorpions, snakes and sandstorms. “The sand is awful,” says Clot. They set off at 5am each morning and trekked for 5 hours, taking shelter during the hottest part of the day, then walked again in the evening. Every fifth day, they paused to rest.

“I misidentified fish as onion – the heat had addled my olfactory bulb”

Throughout, they lent their bodies to science. “We study the individual as much as possible – physiology, epigenetics, microbiota,” says chief scientist Margaux Romand-Monnier at Ecole Normale Supérieure in Paris. “We also [study] cognition and brain plasticity, and then we have another set of studies to investigate how the group evolved and the dynamics and how it changed from the beginning of the expedition until the end.”

Some of the data acquisition was continuous. The climatonauts wore accelerometers to monitor their movement and sleep, and sociometers to record their interactions with other group members – who they are near and whether they are talking, though not the content of the conversation. Every few days, they swallowed a sensor to monitor their core temperature. They also filled in daily questionnaires about their emotional and physical state and recorded what they ate – a monotonous diet of rehydrated meals, flatbreads, processed cheese, dried fruits, nuts and cookies.

On rest days, they all underwent a battery of physical and cognitive tests, including heart rate, blood pressure, posture, muscle

tone and oxygenation, memory, attention, metacognition and sensory perception. (I took a smell test and flunked it, misidentifying fish as onion; the oppressive heat had clearly messed with my olfactory bulb). They had blood and stool samples taken, the latter to assess their gut microbiome.

This vast pool of data, once compiled and cleaned up, will be sent to 13 collaborating research groups for analysis, along with data from the other two expeditions. They will track the changes over time and compare the data with baselines taken before the treks. It will take a year at least to get the full results.

There is some existing research, says Romand-Monnier, but it is limited to short-term physiological adaptation in military personnel and elite athletes. “It’s really frustrating because there is a lot of publications and everybody thinks, come on, we already know everything, what are you going to study?” she says. “But the thing is, for a normal group in that kind of climate and that duration, we know nothing.”

Mind over matter

They do have hypotheses, based on the pilot data from Clot’s solo expeditions. Physiology probably can’t adapt very much, says Clot, but the way we think and operate looks like it can respond positively. “The brain can change a lot, and it can change really fast,” he says, based on his experiences. “After 40 days, a lot of human beings are adapted to new conditions.” It is a case of mind over matter.

For a group of people who have been in the desert for 40 days and 40 nights, the climatonauts all appear remarkably healthy. They were, of course, selected precisely because they had the right stuff. Romand-Monnier acknowledges that this is a weakness of the study, since most people who experience climate extremes in the future won’t be young, healthy, decked out in specialist footwear and clothing, fed and watered. Nor will they know there is a definitive endpoint. But you have to start somewhere, she says, and the plan is to re-run the expeditions with participants who represent different backgrounds and ages.

Understanding how ordinary people respond to extreme climates could hardly be more urgent. In the era before climate change really kicked in, almost nobody lived under extremely hot conditions year-round. In the mid-1960s, perhaps 10 million people lived outside the niche, says Lenton. Today, around 60 million do, overwhelmingly in lower-

Blistering heat, felt here at the Taj Mahal in India, will become common in many countries





Clockwise from left:
Graham Lawton on
the dry heat expedition
in Saudi Arabia;
participants walk in
45°C (113°F) heat
during the day; tents
provide brief respite at
the hottest time of day



GRAHAM LAWTON

income countries such as India, Nigeria and Indonesia. That increase is partly due to population growth, but also climate change.

The current distribution of population density still peaks at a mean annual temperature of 12°C (54°F), but there is now another, smaller peak at 25°C (77°F). That is largely due to people living on the Indian subcontinent, says Lenton, where hotter conditions are becoming the norm. It is within our climate niche, but only just, with frequent heatwaves nudging conditions into extreme heat, which Lenton defines as an annual mean of 29°C (84°F). Even places firmly in the niche will find themselves getting warmer. “A bunch of people might be shifted from what was a really great climate historically, say 12 to 13°C, and are now finding themselves at 17°C or maybe even 20°C,” says Lenton.

The numbers affected will continue to grow as temperatures creep up. If we limit global warming to 1.5°C above pre-industrial levels, says Lenton, extreme heat will descend on areas where 400 million people currently live. If we go to 2.7°C, which is where current climate commitments are taking us, that rises to 2 billion. “In the 2.7°C world, there’s over 600 million people in India and over 300 million people in Nigeria exposed to extreme heat,”

he says, plus many more millions in Indonesia, the Philippines and vast swathes of the Sahel region of Africa.

Notably, of course, these aren’t wealthy countries. Saudi Arabia is rich, and most people there can afford to modify their living spaces to stay within the niche. Not so for lower-income countries on the front line of extreme heat.

“The super rich can find ways of getting inside air-conditioned buildings and sourcing desalinated seawater, and find other ways of continuing to thrive in extreme climates,” says Lenton. “But that only works if you have enough resources. There’s an awful lot of people on the planet still living below the poverty line, a huge number of people who don’t have the means to have access to some of those adaptation options.”

For those people, the most likely adaptation is mass migration. “The normal response is to move to the better places, we see that happening for birds, for plants, and it has happened throughout human history,” says Lenton’s colleague Marten Scheffer at Wageningen University in the Netherlands. “It would be a very natural adaptation to consider migration, and not just migration of tens of millions of people. That might be a billion or so.”

How the world will respond to such mass movement isn’t clear, although the West’s current attitude to much smaller numbers of refugees doesn’t bode well. But the shifting niche will at least create more liveable spaces at higher and lower latitudes. “There is a bright side,” says Scheffer. “Some places are getting worse, but other places are getting better. It’s not like the Earth is becoming unliveable.”

It certainly feels unliveable in the Saudi Arabian desert. My two days there felt like an eternity, and I was relieved to get back to the hotel. Cold beer wasn’t an option – Saudi Arabia is a dry country in more than one sense – but there was air conditioning and a swimming pool. Two out of three ain’t bad.

As the climatonauts had wearily broken camp for the last time, I had asked some what they were looking forward to most once they got home. Most said good food, wine, sleep, showers, family, friends, a bit of solitude – and a respite from the heat. Many more of us will be longing for that in the not-too-distant future. ■



Graham Lawton is a features writer at *New Scientist*

THE 1960 US presidential election saw the first public debates between Republican and Democrat nominees. In a series of four meetings, Richard Nixon and John F. Kennedy duked it out live on television and radio. The upshot was intriguing. Among people who had listened to the debates, Nixon was generally thought to have come out on top. But viewers had Kennedy down as the winner. How could that be?

The answer lies beyond what the two men said. We tend to consider language as the only medium through which we communicate, but there is another channel hidden in our hands: gesture. Even if we are unaware of our gestures, they are visible to anyone who can see us talking. What's more, they seem to have a special hold on the truth. Gestures often give people a window into our thoughts that words don't – which might help explain why Kennedy went on to win the US presidency.

But gestures don't just let other people read our minds. I have spent five decades studying how we communicate with our hands and, together with other researchers, I have discovered the surprising power of gestures to shape our thoughts.

What we have come to realise is that gestures are not mere movements. They are a special kind of thinking that is revealed through the hands. Most people so undervalue them that they often don't realise they are gesturing. Yet the wide range of abilities that gesturing entails makes it a sort of superpower. Understand gesture and you can maximise its benefits to boost learning and memory, communicate more effectively and build deeper social connections.

First, though, what do I mean by gestures? I don't mean the hand signals that everyone agrees on in a particular culture, such as a thumbs-up that means "things are good" in the US and UK. These so-called emblems are like words in a dictionary. They always take the same form, so don't reveal much about the thoughts of the person using them. Instead,

Express yourself

Why do we move our hands when we talk? Psychologist **Susan Goldin-Meadow** reveals the hidden powers of gesture

ANA YAEI

I am interested in spontaneous gestures, movements that we produce with our hands when we speak.

People in all cultures gesture. And you don't need to have seen it done to do it: people who are born blind move their hands when they talk, just as sighted people do. People also gesture alongside using sign language.

An indication of just how deep-rooted gesturing is comes from the intriguing case

“Making gestures has a powerful effect on learning”



study of a man known as IW. As a result of nerve damage caused by illness, he became unable to control his movements. With great effort, IW learned to move his arms and legs, but only when he could see them and visually guide them. He couldn't move or manipulate objects in the dark, yet he could still gesture when he talked – in the light or dark.

IW's experience highlights that gestures aren't like our other movements, and raises

the question of what is going on inside our brains when we gesture. The truth is that we aren't sure. However, we do know that learning with the aid of gesture leaves a signature in the part of the brain associated with movement, just as learning by manipulating physical objects does. Also, when someone simply talks about an action, such as tying their shoelaces, the same areas of the brain are involved as when they actually perform that action. These

observations led Martha Alibali and Autumn Hostetter, both then at the University of Wisconsin-Madison, to propose that the brain simulates actions when we speak about them, and that when a certain threshold of brain activity is reached, this simulation leads to gesture. The threshold may differ from person to person, creating differences in how much people gesture in various contexts.

This would explain why we gesture more when describing things we have done than things we have only seen. But even if this action simulation idea is correct, there must be more going on in the brain because gestures aren't just about our own actions. We use them to represent many other things, including shapes (for example, moving your hand in a circle to represent a ball), the actions of objects (moving your hand upwards to represent a rocket taking off) and ideas (moving your hand forwards to represent the future). Clearly, there is still much we don't know about the neuroscience of gestures.

The question that really intrigues me, however, is why we gesture when we talk. The Nixon/Kennedy debates suggest one possible benefit of this arm gymnastics. Even if viewers don't consciously attend to gestures, they do subconsciously interpret them to glean more information than from speech alone. A recent study suggests that speakers intuitively know this. James Trujillo at the Max Planck Institute for Psycholinguistics in the Netherlands and his colleagues wanted to see what happens to gestures when we try to communicate in a noisy environment. They found that, just as we tend to raise our voices, we also accentuate and elaborate our gestures. In fact, speakers put more effort into exaggerating their gestures than adjusting the volume of their speech.

So, we alter our gestures to help people understand us. But this can't be the whole story, otherwise why would we use our hands when talking on the phone and in other situations where people can't see us? One long-standing idea is that gesturing





BETT MANN ARCHIVE/GETTY IMAGES

“Gesture lightens our cognitive load, making thinking easier”

helps us retrieve tip-of-the-tongue words. You might find yourself rotating your hand as you try to remember the word “screwdriver”, for example. It sounds plausible and some researchers believe it, but the evidence remains inconclusive.

Nevertheless, a slew of experiments convincingly show that gesturing helps our thinking in other ways. For example, in one study, my colleagues and I used eye trackers to watch where children looked during maths lessons in which the teacher either used gestures or avoided using them. When her gestures pointed out the numbers she was talking about, children were more likely to look at these numbers. That isn’t too surprising. However, when we homed in on all the children whose gaze followed

these numbers – even those taught without gestures – we found that children taught with gestures understood more after the lesson than those who hadn’t seen them. So a teacher’s gestures don’t just help learners focus on what is important, they also help them get more meaning from what they attend to.

Making our own gestures has an even more powerful effect on learning. One experiment found that pre-schoolers aged 4 and 5 who pointed at numbers while counting became more accurate counters than children of the same age who only watched a puppet point at the numbers. In addition, gesturing also helps us generalise what we are learning, which is essential for acquiring new knowledge. For example, 4 and 5-year-olds taught the invented

word “tiffing” – meaning to squeeze the round part of a toy – were more likely to extend this knowledge to other squeezable toys if they had learned the word while using a squeezing gesture than if they had learned it while physically squeezing a particular toy. It seems that gesturing helps us abstract away from the details of a problem and think more deeply about how to solve it.

As well as helping us learn and understand, gesturing also aids memory directly. My colleagues and I showed adult volunteers videos of people, animals and toys performing various actions before testing their memory immediately afterwards and again a few weeks later. In the long term, they remembered more items when they had used gesture while describing them afterwards than when they had used words alone.

You might expect that moving your hands and talking at the same time would require more brainpower than talking on its own since doing the two together improves memory. In fact, it seems to do the opposite. We conducted an experiment where adults had to multitask by simultaneously explaining how they solved a maths problem while remembering a sequence of letters. They remembered more, not fewer, letters when they used gestures along with words in their maths explanations than when they used words alone. Instead of adding to our cognitive load, gesturing seems to lighten it, making thinking easier.

One possible explanation for this might be that gesture externalises ideas and puts them in a spatial setting. This is a bit like a



JOHN GAFFNEY/ALAMY

Above: John F. Kennedy gesturing to Richard Nixon.
Left: Astronaut Tim Peake explaining space travel

Tuning in to gestures

Gesture gets its power in part from the fact that it is rarely noticed by the speaker or listener yet is easily understood and incorporated into our conversations. The challenge is to use it to good effect. Here are some tips that can help you take advantage of gesture.

Encourage gesture in your children, students and anyone else you are trying to teach. This will help them understand the material you are conveying. Gesturing while learning will also make them more likely to solve the same problem in a new way. That is important because being able to generalise what we learn is essential to acquiring new knowledge.

Pay attention to other people's gestures. These offer a window into the thoughts that speakers have but don't express in their words. These thoughts are often at the cutting-edge of their knowledge or address issues that are uppermost in their minds. Noticing and responding to such gestures will improve your interactions at home and at work.

Observe the gesturing of infants. While learning to talk, children typically convey sentence-like meanings in a combination of gesture and speech before using words alone – for example, pointing at a box and saying “open”. If a child fails to produce these gesture-word combinations, it may be a sign that their spoken language development will be delayed, allowing you to intervene and help.

Be careful that your gestures say what you want them to. Those you talk to will pay attention to your gestures – although often subconsciously – so choose them wisely. Remember, gestures can reveal what you might want to hide. And if you are questioning someone, be aware that a gesture may inadvertently influence them to tell you what you want to hear rather than give their own unbiased answer.

Gesture more when you speak. It will help you learn and understand, and also think in a more abstract way. If you gesture while talking, you will remember more of what you have said. Do it while you are multitasking and it will lighten your cognitive load. What's more, when you gesture, the people around you tend to do so too. This can give you a way of seeing what others are thinking but not saying.



MOMO PRODUCTIONS/GETTY IMAGES

memory strategy called the “method of loci” where you mentally place each item on a list in a different location and take an imaginary journey around these locations to aid recall. Gesture might work like this too, an intriguing idea that has yet to be tested.

What is clear, however, is that gesture provides an additional mode of thought – more visual than speech and more active than pictures. As such, it can fill gaps left by speech. It is particularly suited to capturing ideas visually – outlining shapes, recreating movements and displaying transformations. And it can communicate information that is implicit in a picture but difficult to express in words. For instance, when Mary Hegarty at the University of California, Santa Barbara, and her colleagues showed people diagrams of mechanical systems and asked them to work out how different parts moved, more than 90 per cent of their explanations were accompanied by gestures. Most of these gestures portrayed mechanical motions not described in their words and not obvious from the diagrams. In this way, gesture provides an extra way of thinking and communicating ideas that speech struggles with.

It is tempting to think that the cognitive power of gesture might lie in the fact that it allows us to use two methods – hand and mouth – at once. But it isn't that simple.

Gesturing can help children learn and solve problems in new ways

My colleagues and I discovered this when we taught a maths concept to hearing children, who used their hands to gesture and their mouths to speak, and to deaf children, who used their hands to gesture and to produce American Sign Language. The result was the same in both groups: children who produced gestures that conveyed different information from their language were more likely to learn how to solve the problems than those whose gestures conveyed the same information as their language.

Nevertheless, the fact that gesturing brings the body into thinking does seem to be important. We know that our movements can have an impact on our thinking. For example, if you learn a new dance while blindfolded, you will subsequently be able to recognise those moves when someone else does them more easily than a dance you didn't perform. Like other movements, our gestures are a form of embodied cognition with the power to shape our thoughts.

The wide range of functions that gesturing serves make it a multi-purpose cognitive tool. But be warned: today's technologies are interfering with our ability to make the best use of it. When you are holding your phone or Zooming in to a meeting or lesson, the rich language of gesture may be partially blocked or missing entirely. On the other hand, when you recognise that gesturing occurs in all contexts, from parenting to your professional and social interactions, then you can take advantage of the benefits it offers (see “Tuning in to gestures”, left).

Understand and embrace its power and I assure you it will fundamentally change how effectively you communicate, for the better. ■



Susan Goldin-Meadow is a professor of psychology at the University of Chicago

Cosmic fireworks

Astronomer **María Arias** explains space's most spectacular light shows and what they reveal about the universe

TO HUMAN eyes, the night sky is serene, save for the moon and a few wandering planets. Peer into space with a telescope that can scan the entire sky in days, however, and it appears as a great cosmic fireworks display – a riot of bangs and flashes radiating across the electromagnetic spectrum, from radio waves to gamma rays.

Astronomers are eager to catch these fleeting astrophysical phenomena, known as transients, because they can reveal a great deal about the universe, from what matter does in the most extreme conditions to how the cosmos evolved. And we are about to see a lot more of them thanks to the Vera C. Rubin

Observatory in Chile, which is expected to detect 10 million transients a night when it switches on next year.

The trouble is that, for the untrained observer, it can be difficult to make sense of transients. For starters, similar-looking outbursts can have different origins and vice versa, such that a single source can give rise to a variety of astrophysical signatures. That alone can make it tricky to keep track of what's what.

Here, then, is a concise primer that also serves as a guide to the causes and consequences of these ephemeral illuminations – and how, in some cases, they challenge our understanding of the physics that governs the universe.

A stylized illustration of a star on the left side of the page. The star is depicted with a small blue core and a larger yellow-orange outer layer. From the star, several white and yellow lines representing magnetic field lines or plasma flows extend outwards. One prominent line curves upwards and to the right, ending near the 'Stellar flares' section. Another line curves downwards and to the right, ending near the 'Classical novae' section. The background is a dark blue gradient with faint, wispy white and yellow lines suggesting cosmic dust or distant starlight.

Stellar flares

A living star's electromagnetic eruptions

Let's start with an easy one. A stellar flare is an explosion in the atmosphere of a star that results in an intense flash of radiation across the electromagnetic spectrum. When our sun flares, for instance, we see a sudden burst of brightness before it quickly returns to quiescence. Something similar goes on in stars of various sizes, temperatures and luminosities.

We know a fair bit about what causes this in our sun. It comes down to its magnetic field, which is carried by the roiling gases that make up every star. These gases are in constant motion due to convection in the outer layers of the sun and our star's rotation, so the magnetic field lines are constantly being stretched and tangled. When the lines come into contact, they merge, releasing huge amounts of energy. At the sun's surface, this quickly heats the surrounding atmosphere and accelerates particles, resulting in sudden outbursts.

Sometimes the excess energy can cause some of the material of the sun to bubble up in a coronal mass ejection. In extreme cases, these reach Earth and interact with its magnetic field, which can endanger satellites and even our ground-based infrastructure. That is why astronomers are constantly monitoring the sun's activity to warn of incoming solar storms.

We are also keen to see flares on other stars, partly so we can see the consequences for any planets orbiting them, which would have huge implications for their habitability. One idea is that stellar flares can expose nascent life on nearby worlds to fatal levels of radiation. But recent research on an exoplanet called Proxima b suggests that flares can make conditions more conducive to life, by changing the atmosphere such that it can retain heat where otherwise it would be too cold.

Classical novae

The fizzling corpses of low-mass stars

Classical novae are bright outbursts from white dwarfs – the exposed, inert cores that remain after low-mass stars (ones of eight solar masses or less) blow out their outer layers at the end of their lives.

Having run through their nuclear fuel, and unable to ignite fusion reactions in the carbon and oxygen that remains, these cores cool and dim as they radiate away heat

from a lifetime of nuclear reactions. Their electrons are so tightly packed that they exert a quantum mechanical pressure known as degeneracy pressure, which prevents the white dwarfs from collapsing in on themselves due to gravity. If a white dwarf is alone, then it will limp on, slowly cooling and dimming. If it has a companion, however, things can get explosive.

In binary systems, where two stars orbit a common centre of mass, one star reaches the white dwarf stage while the other is still actively fusing elements in its core. If the two are close enough, the white dwarf's gravitational field can suck matter away from its companion's surface, which gets deposited on the white dwarf. Typically hydrogen gas, this material heats up as it amasses until the temperature gets so high that nuclear fusion reactions ignite, releasing all their energy at once. The result is a brief surge in luminosity, where the white dwarf becomes tens of thousands of times as bright as our sun.

And it doesn't have to be a one-off. We think that once all the hydrogen is used up, the cycle starts again, leading to recurrent novae. We observe these rarely – in 2021, for instance, we spotted one called RS Ophiuchi, having already seen it erupt in 2006 and 1985. But we think that many novae recur, albeit typically on much longer timescales.

Thermonuclear supernovae

Runaway fusion in a greedy white dwarf

Just like classical novae, the sources of these explosions, often referred to as Type Ia supernovae, are white dwarfs in binary systems. Here, however, as the white dwarf accumulates matter from its companion, its mass increases to the point where degeneracy pressure can no longer resist gravity. This limit is 1.4 times the mass of our sun and is known as the Chandrasekhar limit, after the physicist who calculated it.

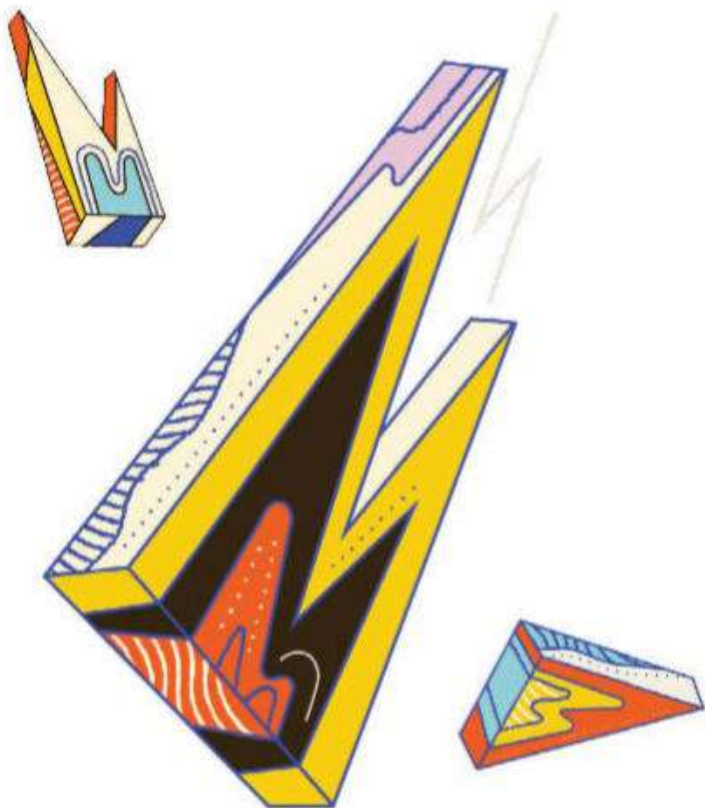
But before the star collapses in on itself, the temperature in its core gets high enough that the carbon it contains can finally ignite into nuclear fusion reactions. This sparks a thermonuclear runaway: the energy produced further increases the temperature, which increases the reaction rate of carbon fusion and so on. Blowing up from its core, the star is obliterated in ➤

an explosion roughly 5 billion times brighter than the sun.

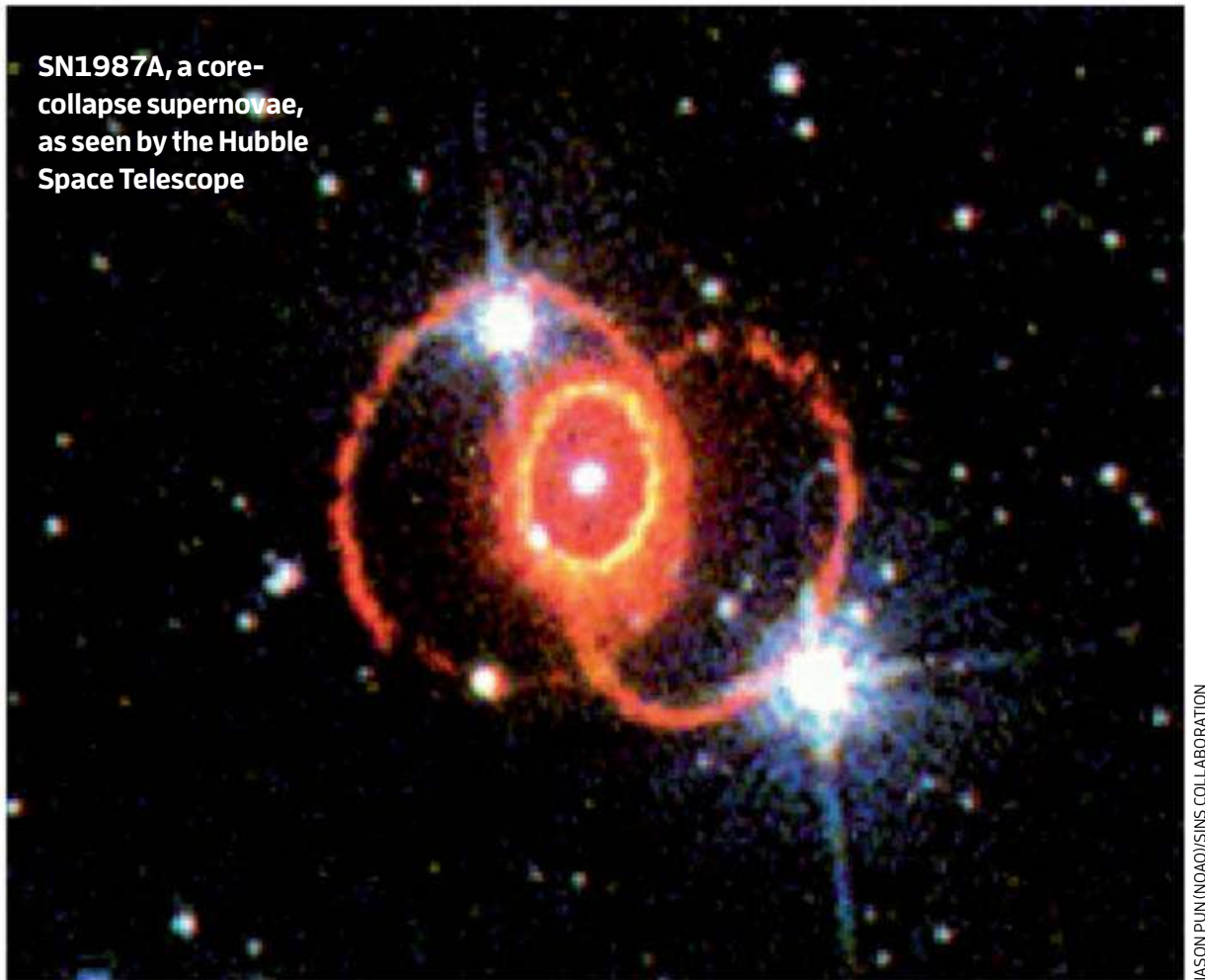
The fact that only white dwarfs close to the Chandrasekhar limit can explode in this way makes them more or less uniformly bright. This is why we call them “standard candles”: if we see one, we know how far away it is from how bright it appears. We have used them to measure the expansion of the universe, and to discover that it is expanding at an accelerating rate, which cosmologists explain by invoking a mysterious entity called dark energy.

But standard candles may not be quite as standard as they first appear. We have found that their brightness can vary depending on the progenitor system, as well as what kind of galaxy they are in. That matters because even tiny inaccuracies in our measurements of cosmic expansion would have big implications for what dark energy might be.

“FRBs release as much energy in milliseconds as the sun does in 100,000 years”



SN1987A, a core-collapse supernovae, as seen by the Hubble Space Telescope



JASON PUN (NOAO)/SINS COLLABORATION

Core-collapse supernovae

The dramatic finales of massive stars

This class of supernovae is distinct from the thermonuclear variety, and indeed classical novae, in that they are explosions from stars that haven't become white dwarfs. It is a big cosmic coincidence that they are roughly as bright and energetic as Type Ia supernovae, because they are very different beasts. They are, essentially, the collapse and rebound of a massive star.

The very biggest stars – those of eight solar masses and above – don't become white dwarfs. The temperatures in their cores are so high that they can fuse increasingly heavy elements until they form iron, which cannot be combined with any other element to release energy. During the star's life, the nuclear reactions in its core provide enough outward pressure to counteract the mass of its layers. But once the core runs out of fuel, it can no longer support the mass of the layers surrounding it and the star collapses in on itself.

The collapse becomes an explosion because all this material changes direction.

We don't quite understand how that happens, but the idea is that the gas in the core becomes so compact that it can compress no more, so that material falling inward from the outer layers bounces off it to create a shock wave. Matter then bursts out from the star at more than 10,000 kilometres a second, releasing a huge amount of energy, which triggers further nuclear reactions. This is the main source of elements heavier than iron in the universe, which enrich the interstellar medium and drive the evolution of the surrounding space.

What remains is some of the mass from the inner layers of the star, which forms either an extremely dense ball of neutrons – a neutron star – or a black hole. These are the most exotic forms of matter in the universe, where the laws of general relativity (Albert Einstein's theory of gravity) and quantum mechanics (which describes the subatomic world) collide. Hence, they lie beyond our current grasp of physics.



New Scientist audio

You can now listen to many articles – look for the headphones icon in our app [newscientist.com/app](https://www.newscientist.com/app)

Kilonovae

Big blasts from colliding neutron stars

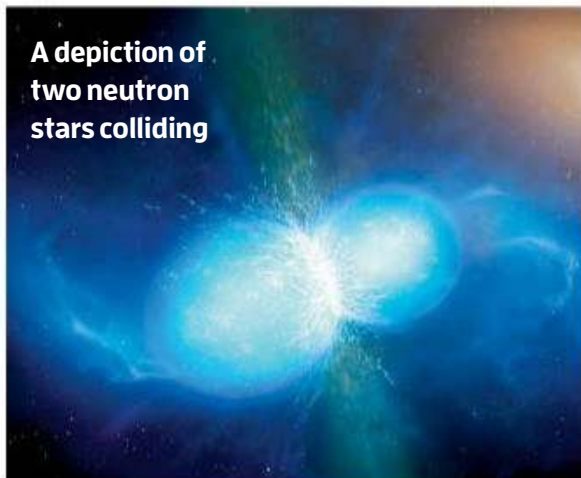
Named for the fact that these bursts are roughly 1000 times brighter than a classical nova (see page 39), kilonovae are produced in a different way to novae and supernovae.

Neutron stars, themselves the extremely dense remnants of some core-collapse supernovae (see page 40), are an exotic form of matter held together by the degeneracy pressure imparted by neutrons. When two neutron stars orbit a common centre of mass, the system releases energy in the form of ripples in space-time called gravitational waves. Eventually, the two neutron stars collide and we see a powerful flash in the optical, infrared and gamma parts of the electromagnetic spectrum.

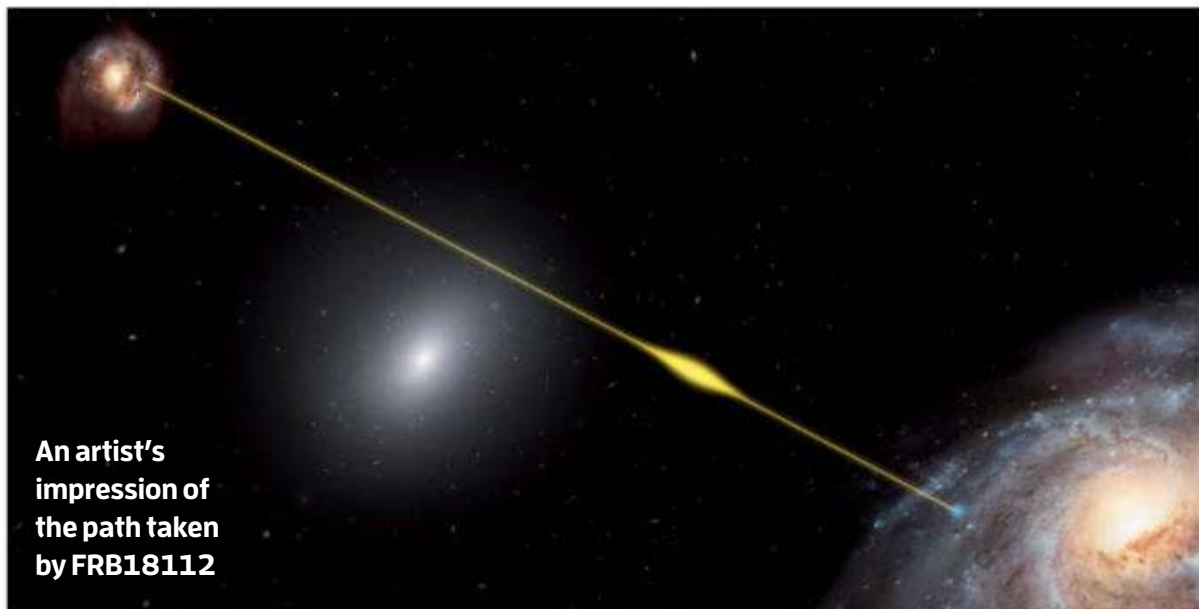
A lot of what we know about these kilonovae comes from a gravitational wave detection known as GW170817. When it was spotted in 2017, facilities that together observe across the electromagnetic spectrum turned to look. This gave us an exquisite dataset that confirmed some long-held hypotheses regarding kilonovae. Firstly, it supported the idea that neutron star mergers produce short and intense bursts of gamma rays. Secondly, it demonstrated that these mergers are the site of a kind of element formation in which neutrons are absorbed into an atomic nucleus, producing heavy metals like platinum and gold.

The remnant left behind after the merger is either a black hole or a larger neutron star. The details of the merger are anyone's guess, though, because we don't have a good grasp of how pressure, density, temperature and composition are related in a gas of neutrons compressed to the point where they can be packed no tighter. This "equation of state" in neutron stars remains one of the biggest open questions in astrophysics.

A depiction of two neutron stars colliding



UNIVERSITY OF WARWICK/MARK GARLICK



An artist's impression of the path taken by FRB18112

ESO/M. KORNMESSER

Fast radio bursts

Mysterious pulses from far far away

First spotted in archival data in 2007, fast radio bursts (FRBs) are incredibly powerful millisecond-duration pulses of radio waves from distant galaxies. Initially, they had astronomers scratching their heads: what kind of event could release as much energy in a fraction of a second as the sun will radiate in 100,000 years?

We spotted a second burst in 2012, and since then the catalogue of FRBs has itself exploded, with more than 675 sightings as of July 2023. As a result, our understanding of them has come on in leaps and bounds.

FRBs are so short-lived and intensely bright that the objects producing them must be incredibly compact. We also know that the radio emission is polarised, which implies the source must have a very strong magnetic field. But the key piece of the puzzle was the discovery of "repeaters", where more than one burst is observed from the same source. This tells us that whatever produces FRBs isn't always destroyed in the process. All of which has led to the widely held idea that FRBs are outbursts from strongly magnetised young neutron stars called magnetars.

Astronomers have also been figuring out how to use these detections to probe distant reaches of space. Each FRB pulse arrives at Earth at a broad band of radio frequencies, and from the time delay between the high and low-frequency signals it is possible to infer some of the properties of the space through which they have

passed. Since, in most cases, the sources of FRBs are in very distant galaxies, the information they encode could tell us about the vast voids between galaxies. That might include insights about the strength of the magnetic fields there and whether they were present in the early universe, which would force cosmologists to rethink the role of magnetism in the evolution of the cosmos.

Gamma-ray bursts

The brightest flashes in the universe

Gamma rays are the highest energy form of light there is, and gamma ray bursts (GRBs) are the brightest and most energetic transient events we have ever seen. They can last from milliseconds to minutes, though they often show an afterglow in X-ray, optical and radio emissions, which has allowed astronomers to investigate the sources that produce them.

We have discovered that there are two distinct populations. Long GRBs, which have a duration of more than 2 seconds and up to a minute, are thought to be produced by core-collapse supernovae (see page 40). The collapse forms a black hole, whipping up the star's remnants into powerful jets. Short GRBs, those of less than 2 seconds, meanwhile, are associated with the merger of compact objects like neutron stars and black holes. This was confirmed in 2017 ➤

when the gravitational wave signal GW170817 was attributed to the collision of two neutron stars and follow-up observations revealed that, in these circumstances, a short GRB is produced alongside a kilonova (see page 41).

Gamma ray bursts continue to serve up surprises, though. In 2022, astronomers spotted the most powerful long GRB we have ever seen and dubbed it “the BOAT” – the brightest of all time – on the basis that it is probably the brightest signal to hit Earth since human civilisation began.

Observations of the afterglow suggest that it may not have come from a supernova, as we would expect, because it wasn’t clear whether there was even one in the vicinity at all. This year, we also spotted a long GRB that seems to have come from the collision of two stars, throwing our understanding of these bursts further into question.

Tidal disruption events

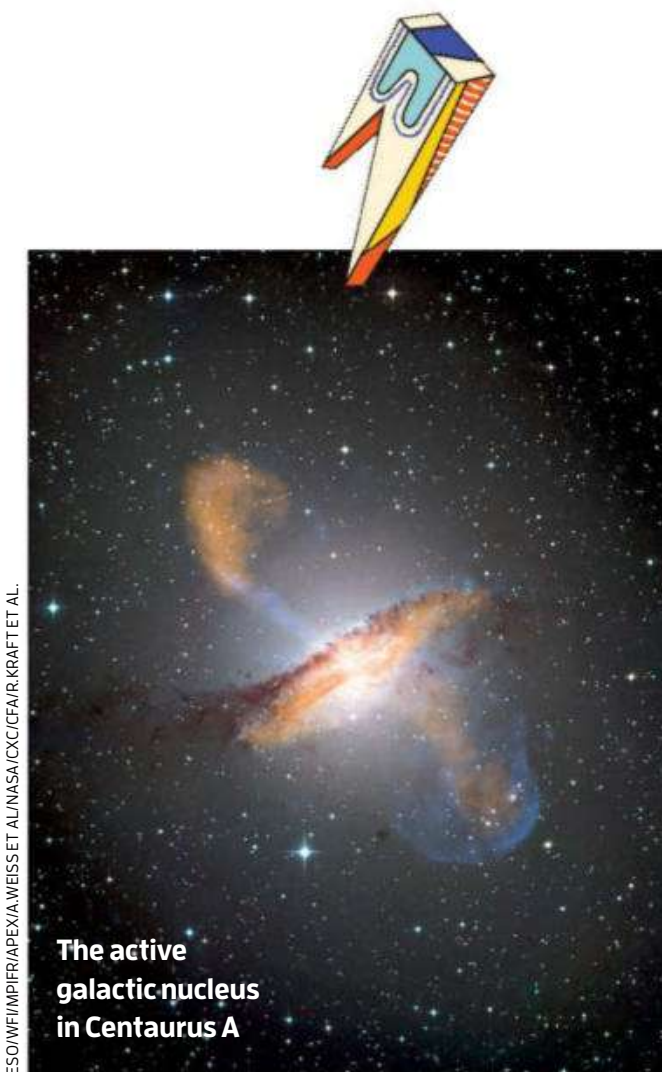
Stars torn apart by hungry black holes

These luminous flares, which tend to last a few months, happen when a star passes too close to a supermassive black hole – the gravitational behemoths that lie at the centre of every galaxy, each with a mass millions to billions of times that of our sun.

For most of us, our experience of tidal forces is limited to seeing the sea level at the beach rise and fall. This happens because Earth and its moon interact gravitationally. As you can imagine, the gravitational pull of a supermassive black hole is much more formidable: when an unfortunate star orbits too close, the tidal forces it experiences are sufficient to completely rip it apart, in some cases launching jets of hot matter and radiation that we see from Earth.

We have only seen about 125 of these events, and it isn’t entirely clear how the jets are generated. But the idea is that, as the star stretches and tears, some of its material coalesces into a disc around the black hole – and the black hole’s gravity, in turn, causes this material to spin and heat up. Thanks to the magnetic fields and the conservation

“A tidal disruption event provides a window into a supermassive black hole’s diet”



ESO/WFI/MPFR/APEX/AWEISSE ET AL/NASA/CXC/CFA/R. KRAFT ET AL.

of angular momentum, the material in the disk accretes onto the black hole, producing bright flares. In the right conditions, jets can form.

Tidal disruption events can tell us about supermassive black holes, from their mass to the physics that produces jets. But my personal favourite is that each is a specific instance of how a black hole consumes matter and grows over time. In other words, they are windows into a black hole’s diet.



Active galactic nuclei

Supercharged jets that outshine entire galaxies

Staking a claim as the most dramatic of all the transients, active galactic nuclei (AGNs) are essentially gigantic accretion events around supermassive black holes that can emit so much radiation, again in the form of jets, that they outshine the entire host galaxy. When these jets are pointed directly at Earth, we call them blazars. When they are only slightly angled toward us, they are known as quasars.

AGNs produce such powerful jets because accretion is one of the most efficient ways of transforming gravitational potential energy into other forms of energy, such as heat and radiation. As gas and dust swirls ever closer to the supermassive black hole, their gravitational potential energy is transformed into heat, which is radiated away as electromagnetic waves.

What makes AGNs so dazzling, however, is that accretion can also trigger what we observe as jets of radio waves. These jets can reach many times further than the outer reaches of their host galaxy.

But astronomers are interested in active galactic nuclei primarily because they play a crucial role in the evolution of galaxies. As the supermassive black holes that produce them cycle through periods of activity and quiescence, they produce a series of feedback effects in the gas and dust in the host galaxy. These, in turn, drive episodes of star formation, energise the interstellar medium and increase the black hole’s mass – all with huge consequences for the way their host galaxies grow. Observations of AGNs from the distant, and therefore early, universe also provide clues to the mystery of how supermassive black holes form, which remains one of cosmology’s biggest mysteries. ■



María Arias is a radio astronomer at Leiden University in the Netherlands

Subscriber Benefits

NewScientist



Online event

Ageless: How science can help us live longer and better

22 August, 6-7pm BST, 1-2pm EDT and on demand

Join Andrew Steele, a computational biologist and science writer, as he reveals the true process of ageing and the practical ways we can help slow it down. Find out how uncovering the scientific implications of ageing could lead to the greatest revolution in the history of medicine – one that has the potential to improve billions of lives, save trillions of dollars and transform the human condition.

**To register your place, visit
newscientist.com/ageing**

You will need your 12-digit subscriber number which can be found on our customer service and event emails, and above your address on your print copy.

HURRY
Last
chance to
register

Scan me
to register



Puzzles

Try our crossword, quick quiz and logic puzzle **p45**

Almost the last word

What was used to wean babies in prehistory? **p46**

Tom Gauld for New Scientist

A cartoonist's take on the world **p47**

Feedback

A case of mistaken AI identity and baring one's teeth **p48**

Twisteddoodles for New Scientist

Picturing the lighter side of life **p48**

Mathematics of life

Luck of the draw

Lotteries have been around for millennia. **Peter Rowlett** has a few psychological tricks up his sleeve to improve your chances today



Peter Rowlett is a mathematics lecturer, podcaster and author based at Sheffield Hallam University in the UK. Follow him @peterrowlett

WOULD you think I was daft if I bought a lottery ticket for the numbers 1, 2, 3, 4, 5 and 6? There is no way those are going to be drawn, right? That feeling should – and, mathematically, does – actually apply to any set of six numbers you could pick.

Lotteries are ancient. Emperor Augustus, for example, organised one to fund repairs to Rome. Early lotteries involved selling tickets and drawing lots, but the idea of people guessing which numbers would be drawn from a machine comes from Renaissance Genoa. A common format is a game that draws six balls from 49, studied by mathematician Leonhard Euler in the 18th century.

The probabilities Euler investigated are found by counting the number of possible draws. There are 49 balls that could be drawn first. For each of these, there are 48 balls that can be drawn next, so there are 49×48 ways to draw two balls. This continues, so there are $49 \times 48 \times 47 \times 46 \times 45 \times 44$ ways to draw six balls. But this number counts all the different arrangements of any six balls as a unique solution.

How many ways can we rearrange six balls? Well, we have six choices for which to put first, then for each of these, five choices for which to put second, and so on. So the number of ways of arranging six balls is $6 \times 5 \times 4 \times 3 \times 2 \times 1$, a number called 6! (six factorial). We divide $49 \times 48 \times 47 \times 46 \times 45 \times 44$ by 6! to get 13,983,816, so the odds of a win are near 1 in 14 million.

Since all combinations of



JOEL SAGET/AFP VIA GETTY IMAGES

numbers are equally likely, how can you maximise your winnings? Here is where maths meets psychology: you win more if fewer people share the prize, so choose numbers others don't. Because people often use dates, numbers over 31 are chosen less often, as well as "unlucky" numbers like 13. A lot of people think of 7 as their favourite number, so perhaps avoid it. People tend to avoid patterns so are less likely to pick consecutive or regularly spaced numbers as they feel less random.

In July, David Cushing and David Stewart at the University of Manchester, UK, published a list of 27 lottery tickets that guarantee a win in the UK National Lottery, which uses 59 balls and offers a prize for matching two or more. But a win doesn't always mean a

profit – for almost 99 per cent of possible draws, their tickets match at most three balls, earning prizes that may not exceed the cost of the tickets!

So, is a lottery worth playing? Since less than half the proceeds are given out in prizes, you would probably be better off saving your weekly ticket money. But a lecturer of mine made an interesting cost-benefit argument. He was paid enough that he could lose the cost of a ticket each week without really noticing. But if he won the jackpot, his life would be changed. So, given that lottery profit is often used to support charitable causes, it might just be worth splurging. ■

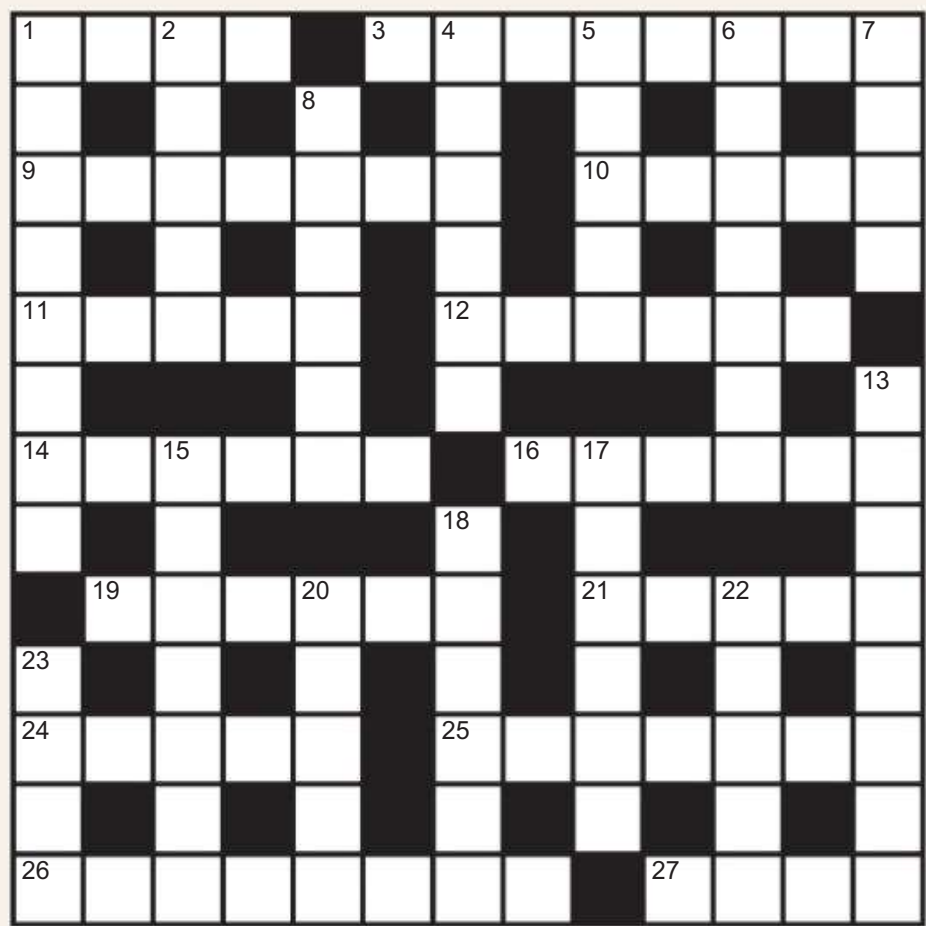
Mathematics of life reveals the mathematical ideas and shortcuts behind everyday situations

Next week

Debunking gardening myths

These articles are posted each week at [newscientist.com/maker](https://www.newscientist.com/maker)

Cryptic crossword #116 *Set by Wingding*



Scribble zone

Answers and the next quick crossword next week

ACROSS

- 1** Places where people drink 7 Down
21 Across outside Belgian capital (4)
3 A cat and another cat holding
mega-weapon (4,4)
9/23 Coach admits exchanging 7 21 (7,4)
10 Surveyed calcium and
selenium at start of day (5)
11 King in Asian country missing a primate (5)
12 Made a home, somehow
set inside new den (6)
14 High-pitched noise coming
from grotesque alien (6)
16 Initially, private healthcare lets
everyone get more 7 21 (6)
19 Space programme officially
opening after a vote (6)
21 Virus identification liquid (5)
24 Fish with massive head is a lucky thing (5)
25 I see Tim updated list (7)
26 Be the dad at sea, where one
hasn't got much time left (8)
27 Brought back some special mushrooms (4)

DOWN

- 1** Perhaps mouse that eats Japanese food,
leaving starter, is most demanding (8)
2 Extremely bold to go around
toilet getting 7 21 (5)
4 Pacific island swaps last of fruit for
new product made from seeds (6)
5 Twitter boss fails to finish collecting
copper's 7 21 (5)
6 Disgusting place south of Russian river (7)
7 God finally discovered in
child's physical form (4)
8 7 21 sadly brought up around 4 Down (6)
13 Small insects absorbing nitrogen
in tiny amounts (8)
15 A slap-up meal, somewhere
in Scandinavia (7)
17 Carried that man over newspaper editor (6)
18 Second 7 21 is able to move freely (6)
20 Poorly MP has to donate 7 21 (5)
22 University researchers investigating
new energy sources produce 7 21 (5)
23 See 9 Across

Quick quiz #215

set by Bethan Ackerley

- 1** What is the only mammal wholly covered in scales?
2 The natural limit to the luminosity of stars is named after which astronomer?
3 In which organ would you find parietal cells, also known as oxyntic cells?
4 Of the following types of volcanic eruption, which is the weakest: Strombolian, Surtseyan or Vulcanian?
5 Name the first halogen in the periodic table.

Answers on page 47

Headscratcher

set by Katie Steckles
#235 Sneak a peek

At the funfair, 10 pots are stacked in a line along a shelf. Under two adjacent pots are the two keys that are needed to unlock the prize cabinet that contains a soft toy.



It costs £1 to enter the game, and all you have to do is guess which two pots you think the keys are under, for example you could say "8 and 9" – but your odds of guessing correctly first time are low.

However, before playing you can also pay extra to "sneak a peek" under one or more pots, at a price of £1 per pot. You can buy as many of these sneak peeks as you want, but you have to specify in advance how many you want to buy. You aren't allowed to pay for extra ones after your first peek.

What is the least you need to spend on peeks if you want to guarantee that you will win the soft toy?

Solution next week



Our crosswords are now solvable online
[newscientist.com/crosswords](https://www.newscientist.com/crosswords)

Solid ground

If 21st-century babies are weaned on a globalised diet that has only recently been available, what was used to wean babies in prehistoric times?

Chris Stantis and Kirsten Verostick
University of Utah, US

That is an amazing question, and something that has led several archaeologists to focus on early childhood diet and feeding practices. We know nutrition in early years has key outcomes for wellness throughout a person's life, and individual health can shape population dynamics and culture.

What babies ate is a difficult question to approach at an archaeological site, as a person's food waste is often thrown away in communal refuse heaps (imagine trying to separate who ate what by going through your own rubbish). By chemically analysing the skeletons of children throughout history and prehistory, archaeologists estimate that babies

“What babies ate is a difficult question at an archaeological site: try separating who ate what by going through your own rubbish”

have often been introduced to complementary foods at around six months old (which is also when the World Health Organization cautions that breast milk alone isn't enough for infant health).

Through historical texts, modern hunter-gatherer strategies and artefacts, we can see across the pre-globalised world that infants were often fed altered forms of what was available to everyone. Those who grew grains (maize, wheat or rice, for example) would prepare porridges; if dairy was part of the diet, then milk, cheese or yogurt could be included for key nutrients. Vegetables and fruits were used, of course, and honey appears as

a complementary food during the weaning process for many societies, possibly for both its caloric richness and its medicinal properties. Meat and seafood could be cooked down or chewed by a caretaker.

As today, all of this depends on what the baby would actually eat!

Hillary Shaw

Newport, Shropshire, UK

Globalisation has vastly increased the range of specific foods we eat, but the broad food groups remain much the same as in preindustrial, even prehistoric, times. Before farming began, fruit and vegetables were collected (root vegetables store well in cool, underground places), wild grass seeds yielded flour for bread and animals and fish were caught.



Want to send us a question or answer?

Email us at lastword@newscientist.com

Questions should be about everyday science phenomena

Full terms and conditions at [newscientist.com/lw-terms](https://www.newscientist.com/lw-terms)



FILED IMAGE/SHUTTERSTOCK

This week's new questions

Cold spell If a northern hemisphere “ice age” is triggered, say due to the Gulf Stream failing, is it inevitable in the southern hemisphere too? *Jane MacDonald, Hobart, Tasmania, Australia*

Itchy and scratchy Are gnats attracted to eyeballs, or are those near our eyes simply the ones we notice most? *Helen Haller, Pittsford, New York, US*

If the northern hemisphere enters an “ice age”, will the southern hemisphere too?

That started the conflicts and innovation we call “history”. But the foods people ate weren't so different before then.

Guy Cox

Sydney, Australia

First of all, in ancient societies, babies were breastfed for much longer than is usual in our modern world. By the time they were fully weaned, they were probably hunting and gathering in their own right (or pretending to).

As to what they were fed, it would hardly be the same in Asia, Africa, Australia and Europe. But there would be common ground – vegetables that could be mashed, fruit that was either soft enough to eat or was easily softened. If the clan feasted on a freshly caught animal, crushing a long bone between two stones would provide tasty and nourishing bone marrow, which was easy for the little kids to swallow. If nothing else was handy, a parent could always chew on something then pass it to their child.

Agriculture provided many more choices, but that wasn't really prehistoric. By the way, my wife and I made very little use of multinational baby foods when our children were little – we were determined to prepare their food ourselves (with the help of modern technology, of course).

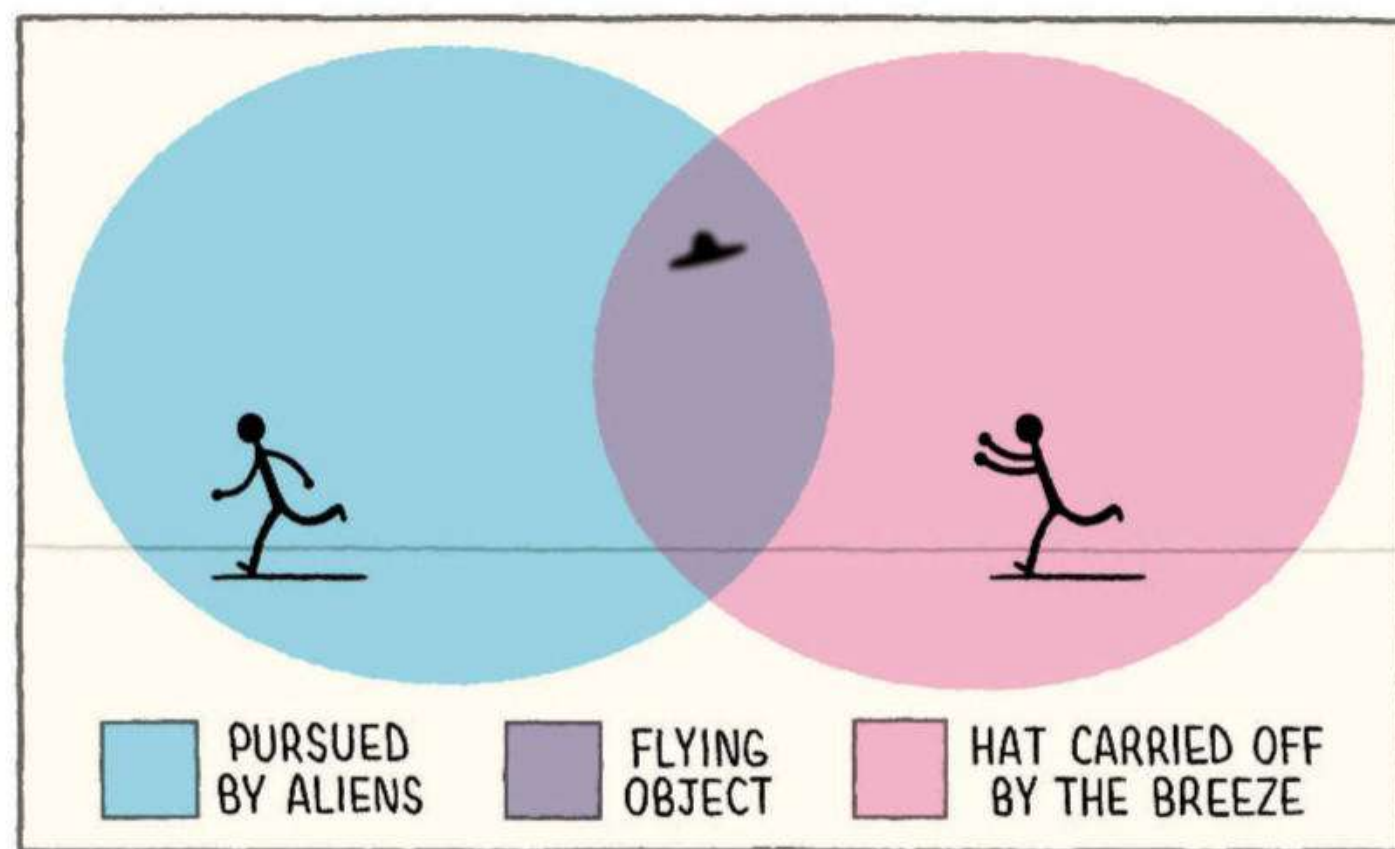
Garry Trethewey

Arkaroola Wilderness Sanctuary, South Australia

I suspect this question is less to do with a child's transition from breast milk to solids and more to do with the dominant Western way of seeing the world. It doesn't ask how babies wean themselves, it asks how an agent (an adult) operates on the baby. This tends to happen where babies have no opportunity to try things for themselves.

I submit that nothing “was used” to wean babies. If we look at some traditional cultures, there is

Tom Gauld
for *New Scientist*



a length of time that breastfeeding “just happens”, as it does in many wild mammals. At this time, the baby puts things in its mouth – a rock, a stick, some food taken from its mother. With wallabies, the baby hangs out of the pouch and tastes things. It eventually learns what is good and what isn’t. Later, whether by the mother’s refusal or its own lack of interest, the baby no longer feeds from a nipple.

All in the mind

Why can’t we conjure up smell and touch in our heads, but we can “listen” to music when nothing is coming through our ears?

Tony Durham
Brighton, UK

I can imagine the smell of roses, ammonia or strawberry jam, and I can imagine how almost any object would feel to touch. I assumed that most other humans shared these abilities.

Psychologists have coined a term, *aphantasia*, for an inability to form visual images in the

“I can imagine the smell of roses or ammonia. I assumed that most other humans shared these abilities”

“mind’s eye”. I am unaware of any studies of the distribution of olfactory and haptic imagery in the population. But if no one has looked into this already, it is surely time to do so.

Quentin Macilray
Poole, Dorset, UK

I am sure perfumiers can indeed conjure up smells in their heads, and probably many other people can too. It is most likely a matter not just of aptitude, but also of practice. Try to conjure up your favourite smell. Go on, use your imagination. Freesias, anyone?

It is similar for touch, for anyone who exercises that sense professionally. Think of people who handle different textiles, such as wool and silk, or doctors who regularly palpate patients.

T. Spinney
Bristol, UK

I am sorry to have to disabuse John Howes of his belief that smell and touch can’t be conjured up in the mind. As your feature “Where’s your head at?” (19 July, p 23) points out, our internal representations of the world differ. I, for one, can conjure up both smell and touch and can even imagine novel flavour combinations, something I often do when cooking.

Dave Wardell
Todmorden, West Yorkshire, UK

I can “conjure up” tastes and smells. It is easiest with basic items like strawberry, steak, bacon, cheeses and a particular aftershave. For some tastes, I can’t separate the mouthfeel from the taste, so my favourite dark chocolate bar with whole hazelnuts can’t be “tasted” without also being aware of the crunch.

I am not really able to hold a clear visual image of an object, let alone a scene, though, so maybe there is a trade-off. ■

Answers

Quick quiz #215 Answers

- 1 The pangolin
- 2 Arthur Eddington
- 3 The stomach
- 4 Strombolian
- 5 Fluorine

Quick crossword #139 Answers

ACROSS 1 Spherometer, 7 Gum, 9/27 Simon Singh, 10 Niels Bohr, 11 Middle ear, 12 Pauli, 13 Isthmus, 15 Muon, 18 Stud, 20 Fifteen, 23 Throb, 24 Scapa Flow, 26 Resilient, 28 Sun, 29 Cut-and-paste

DOWN 1 Sesamoid, 2 Humidity, 3 Renal, 4 Mangles, 5 Theorem, 6 Rustproof, 7 Grow up, 8 Merlin, 14 Metabolic, 16 Wetlands, 17 Snowshoe, 19 Dissect, 20 Flatten, 21 Uterus, 22 Arcsin, 25 Aesop

#234 Remember December Solution

New Year’s Eve (and Craig and Maria’s first kiss) would have been on a Sunday. They gave gifts on every Monday and Thursday of December, and an equal number of gifts were given by both, so there would need to be the same number of Mondays as Thursdays. Given 31 days in December and seven days a week, there are always three consecutive days of the week that appear five times in the month, and four consecutive days of the week that appear four times. The only way for a Monday and Thursday to appear the same number of times is if they appear exactly four times each, with the first Monday falling on the 4th and the last Thursday on the 28th. So New Year’s Eve, 31 December, would have been a Sunday.

Al's AI ailment

AI spells trouble for all the Alanas, Alannas, Alannahs, Alainnas, Alans, Alains, Allans, Allens, Alens, Alins, Aluns and other persons whose names begin with the letter pair "A then L" or the pair "A then I". The eye-ell typography equivalence problem ails them all.

Alan (AI) McWilliam tells Feedback about his personal distress from reading about artificial intelligence: "I would like to draw your attention to a concerning issue where, in the majority of typefaces, the abbreviation for artificial intelligence (AI) looks alarmingly like the shortened version of my (and many others') name, Al. Imagine my trepidation opening the 29 July issue [of *New Scientist*] with the title 'Living with AI! The issue includes 'What AI can do to make your life easier', 'Why AI is about to transform the economy' and 'The biggest scientific challenges that AI is already tackling'. Finally, the most concerning: 'Can AI ever become conscious?'"

AI researchers often discuss "the consciousness problem" – the philosophical difficulty of agreeing whether artificial intelligence is conscious or ever can be. (This adds to philosophers' long-time delight in down-the-rabbit-hole arguing about the meaning of the word consciousness). Feedback notes only that comic book writers once gloried in filling speech balloons with ejaculations that echoed this same problem: "AIEEEEE!"

Pulling teeth

If you first take 33 teeth – each removed from its original home inside some human mouth – then stain every one with coffee, then, finally, on each tooth apply either a "charcoal-based tooth whitening dentifrice" or a "non-charcoal-based whitening dentifrice" to try to remove the coffee stains, you will discover something.

Aldridge Fernandes and Rupali Agnihotri, both at the Manipal Academy of Higher Education, India, did those things.

Twisteddoodles for New Scientist



Got a story for Feedback?

Send it to feedback@newscientist.com

or New Scientist, 9 Derry Street, London, W8 5HY

Consideration of items sent in the post will be delayed

They discovered, they say, that "a charcoal-based tooth-whitener does not make a tooth appreciably whiter than a non-charcoal-based tooth-whitener".

If you choose to do the same experiment – to see if your discovery matches theirs – go find details of their procedure in a paper called "Evaluation of the efficacy of a charcoal-based tooth whitening dentifrice on coffee stains: an in vitro study", in the *Canadian Journal of Dental Hygiene*.

Thirty-three isn't such a large number of teeth. More could surely be obtained, from other donors. Much remains to be discovered, perhaps – perhaps.

Sweet treat

A piece of i-candy – intellectual candy – is the first thing you will

see when you read a paper called "Corrosion resistance of orthodontic wire made of Gold 18K alloy in artificial saliva in the presence of Éclairs milky candy". Written by a team in India and Serbia, it appears in the *International Journal of Corrosion and Scale Inhibition*.

The very first sentence says: "Beautiful objects are symmetrical in nature." For some artists, for some philosophers, for some theoretical physicists, that may seem an eternal basic truth. For anyone else, especially anyone who has a sweet tooth, that statement may be an act of seduction-by-Éclairs-milky-candy.

Engineering research can involve highly specific actions, and the aftermath thereof. Such is the case here. We are told that in the experiment, the "Gold 18K" alloy becomes "immersed in artificial saliva in the absence and presence

of 500 ppm of Éclairs milky candy".

After telling us about the immersions and some subsequent measurements and calculations, the authors get to the basics of What Really Happened. "It is inferred," they state, "that the corrosion resistance of Gold 18K alloy in artificial saliva increases in the presence of Éclairs milky candy." This happy news leads them to advise that "people clipped with orthodontic wire made of Gold 18K alloy need not hesitate to take Éclairs milky candy orally".

Why did these researchers undertake this experiment? Grace smiles from their explanation: "Unfortunately, by God's grace, some people do not have regularly arranged teeth. To regularize the growth of teeth, people need the help of dentists." Some of those dentists affix orthodontic wire made of 18-carat gold alloy to some of those teeth. Inexorably, some tooth owners do not resist eating Éclairs milky candy or other tasty, sugary, milk-fatty treats. Also inexorably, as we see here, some researchers do not resist measuring the resultant corrosion resistance.

Lambe to Slaughter

Nominative determinism sometimes leads to poignant explorations. Pam Ross alerted Feedback to the existence of Nicola Lambe, who does research on sheep breeding. Lambe's latest publication explores a potential future happy phase of life for lambs: motherhood. But the report's title also obliquely mentions a grim alternative fate: dinner. Lambe's study is called "Genetic associations of ewe body condition score and lamb rearing performance in extensively managed meat sheep".

An equally awkward mix of yin and yang greeted readers of the magazine *New Zealand Meat and Wool* in 1977. A report there called "Tapeworm drenching of young lambs – is it worthwhile?" was written by a human named R.D. Slaughter. ■
Marc Abrahams

GALAXY

ON GLASS

SPECTACULAR WALL ART FROM ASTROPHOTOGRAPHER CHRIS BAKER

Available as Acrylic, Framed & Backlit
or Fine Art Prints. All Limited Edition

www.galaxyonglass.com
chris@galaxyonglass.com +44 (0) 7814 181647



SUMMER DISCOUNT

Take advantage of a 15% discount on all images:
just use the code SUMMER23 at checkout



To be ahead in Asia, be on the ground.

abrdn Asian Investment Trusts

In Asia, life and business move fast. To invest here successfully, you need local knowledge.

abrdn has had investment teams in Asia for almost 40 years. So we get to know markets, companies, trends and innovations first hand. And you get to select from investment trusts featuring the most compelling Asia opportunities we can find.

To harness the full potential of Asia, explore our Asian investment trusts on our website.

Please remember, the value of shares and the income from them can go down as well as up and you may get back less than the amount invested. Asian funds may invest in emerging markets which can carry more risk than developed markets.

Request a brochure: 0808 500 4000
invtrusts.co.uk/asia

Issued by abrdn Investments Limited, registered in Scotland (SC108419) at 10 Queen's Terrace, Aberdeen, AB10 1XL, authorised and regulated in the UK by the Financial Conduct Authority. Please quote Q313.

